THE
BRITISH JOURNAL OF SURGERY

VOL. XXXVI JANUARY, 1949 No. 143

PLAIN RADIOGRAPHY IN INTRASPINAL PROTRUSION OF LUMBAR INTERVERTEBRAL DISKS: A CORRELATION WITH OPERATIVE FINDINGS*

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SINCE the pioneering work of Hampton and Robinson (1936) the value of routine radiography of the lumbo-sacral region in cases of suspected disk protrusion has been regarded chiefly as a negative one. It is generally agreed that plain radiography is essential, not so much to verify or substantiate the diagnosis, as to eliminate other pathological processes which may give rise to a similar clinical syndrome. Thus it may reveal the presence of spondylolisthesis, sacro-iliac disease, inflammatory disease of the vertebra, neoplasm, fracture, or other conditions which may simulate a disk protrusion. The detection of any one of these lesions, however, does not exclude a disk prolapse, and although many authorities appear to have found plain radiography of little positive value in diagnosis (Hampton and Robinson, 1936; Love and Camp, 1937), others have noted signs suggestive of disk protrusion in proportions varying from one-fifth (Arbuckle, Shelden, and Pudenz, 1945), to one-half of their cases (Dandy, 1944; Gillespie, 1946).

These differences of opinion appear to have arisen principally because it has not always been appreciated that intraspinal protrusion of an intervertebral disk is merely one of the ways in which its degeneration may become manifest. Indeed, if any signs of disk degeneration can be detected radiologically, disk prolapse is likely at that level. Narrowing of the intervertebral spaces and structural changes in the opposing surfaces of the vertebral bodies, for instance, have been described as isolated phenomena, whereas in reality they are only facets of the degenerative process. In our experience it has been possible to obtain, by plain radiography alone, signs suggestive of the likelihood of a disk protrusion in four out of five patients in which the condition had been diagnosed clinically, and in more than half this number the probable level of the prolapse has been accurately forecast. Our observations will now be discussed.

PATHOLOGICAL BASIS OF DISK PROTRUSION

Many authorities consider that, before a posterior disk protrusion can develop and encroach upon the spinal canal, the intervertebral disk must already have developed degenerative changes (Hyndman, 1946; Rabinovitch, 1947). Prolapse of a normal disk is probably uncommon, for, if severe violence is applied to a structurally normal spine, the vertebral bodies will fracture before the disk ruptures.

Degenerative changes may commence shortly after puberty, and may be well advanced even by the age of 25 years. Indeed, systematic post-mortem studies have shown that "in the middle decades of life, as much as in the later, well-preserved disks are the exception rather than the rule" (Beadle, 1931). The initial change appears to be one of premature senescence with desiccation of the nucleus pulposus, in which the constantly recurring "slight shocks of normal life" play their part (Beadle, 1931). Calcium deposits may occur in the degenerate nucleus. As degeneration proceeds, the nucleus pulposus may burst its confines, as when it prolapses, either vertically through the cartilage plate into the spongiosa of a vertebral body, or posteriorly through the annulus fibrosus into the spinal canal. A prolapse within the spongiosa will in due course excite a thin reactionary layer of dense bone around its periphery, and it then becomes demonstrable radiologically as a 'Schmorl's node', but a posterior disk prolapse usually is not directly visible, except very rarely when the nucleus pulposus is calcified. These degenerative changes lead to a narrowing of the disk space. As diminution in width of the disk continues, the paravertebral ligaments become slack, the mobility of the joint between the vertebral bodies increases, causing bony outgrowths to develop at the margins of the opposing surfaces of the vertebral bodies which may become sclerotic (hypertrophic osteo-arthritis, spondylosis). Over a period of years these osteophytic outgrowths may interdigitate and fuse, restoring the stability of the spine.

Although posterior disk protrusions are usually not directly visible in plain radiographs, the various associated degenerative changes may produce such radiological abnormalities as narrowing of a disk space, calcification of the nucleus pulposus, Schmorl's node, marginal osteophytes, and sclerosis of the opposing surfaces of the vertebral bodies. The detection of any one of these radiological signs may then prove helpful in indicating the level of the disk which is likely to be the site of a posterior protrusion.

* Received for publication July, 1948.

CASE MATERIAL

The case material for this paper consists mainly of 100 consecutive patients submitted to operation with a diagnosis of lumbar disk prolapse. This group has already been studied in connexion with

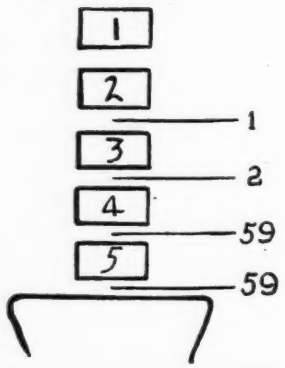


FIG. 313.—Diagram showing levels of disk protrusion in 100 cases (121 prolapses).

myelography, operative findings, and clinical findings (Begg, Falconer, and McGeorge, 1946; Falconer, McGeorge, and Begg, 1948, a, b). Symptoms of

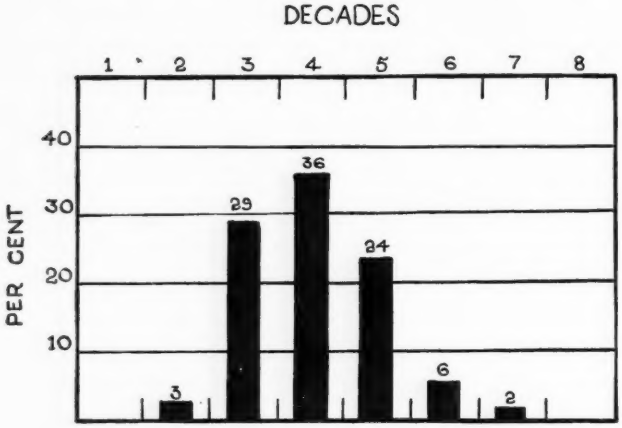


FIG. 314.—Graph illustrating age incidence of lumbar disk prolapse in 100 consecutive cases. Numerals signify the number of patients in each decade.

sciatica predominated in 77 cases and symptoms of low-back pain in the remaining 23, while in all but one case disk lesions were subsequently demonstrated at operation. Multiple prolapses were found in

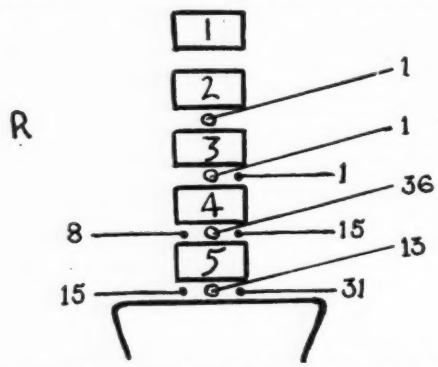


FIG. 316.—Diagram showing sites of protrusion in 100 cases (121 prolapses).

20 patients, and 97 per cent of all prolapses were situated at one or other of the lower two lumbar intervertebral disks, occurring with equal frequency at each of these levels (*Fig.* 313). Seventy-three patients were males and 27 were females, and their ages ranged from 16 to 60 years, with a preponderance in the third, fourth, and fifth decades of life. The age and sex distributions are illustrated in *Figs.* 314, 315.

The precise distribution of the various disk prolapses as demonstrated at operation is shown in *Fig.* 316. It will be seen that 51 (42 per cent) presented in the midline, and 70 (58 per cent) to one side. The ratio of central to lateral prolapses was as 3 to 2 at the fourth lumbar disk space and approximately as 1 to 3 at the fifth lumbar disk space. Also prolapses occurred twice as often on the left side as on the right. The significance of these various distributions is not understood by us.

METHOD OF EXAMINATION

Routine Radiography.—For a survey of the lumbosacral region two projections—lateral and postero-anterior (or rarely anteroposterior)—are employed as a routine. If examination of these films suggests the necessity, oblique, angled, or

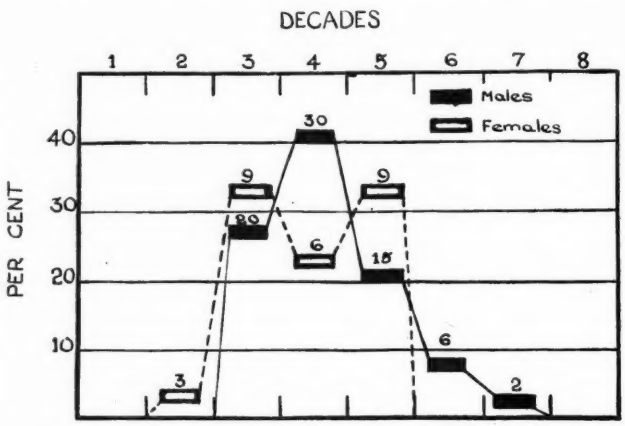


FIG. 315.—Graph showing age and sex incidence in the same group.

stereoscopic views are also taken, but although these may be helpful in demonstrating changes in the sacro-iliac and interlaminar joints, they seldom reveal additional information concerning the intervertebral disks. The routine films should include both the twelfth thoracic vertebra and the sacro-iliac joints, for lesions separated as widely as these two levels may simulate a lumbar disk syndrome.

As detection of degeneration of the intervertebral disks depends largely upon a comparison of the widths of the various interspaces, and the character of the contiguous surfaces of the vertebral bodies, it is desirable that all should be seen on a single film. Great care must be exercised in positioning the patient, as a faulty technique may make a normal disk appear narrow, or may obscure significant osteophytic outgrowths. Due to anatomical and physical considerations, the standard anteroposterior view and the standard lateral view made with spine parallel with the radiographic table fail to show the

intervertebral spaces with sufficient accuracy. The method we adopted took advantage of the divergence of rays from the anode, to show clearly all the lumbar interspaces and vertebral bodies, in both the coronal and sagittal planes.

a. Lateral Projection.—If each intervertebral space is to be represented accurately on the film, the rays must pass through each parallel with the opposing surfaces of the vertebral bodies. For this to occur the line of the lumbar spine must not be straight, but must form the arc of a circle whose radius is the distance between the anode of the tube and the central point of the lumbar spine (*Fig.* 317). Few patients have a perfectly straight spine, and indeed many have a slight but definite scoliosis. When the patient is positioned, therefore, the convexity of the spinal curve is directed towards the radiographic table. The line of the lower thoracic and lumbar spine is then marked with a skin pencil, and the X-ray tube centred over the third lumbar vertebra. Next, the

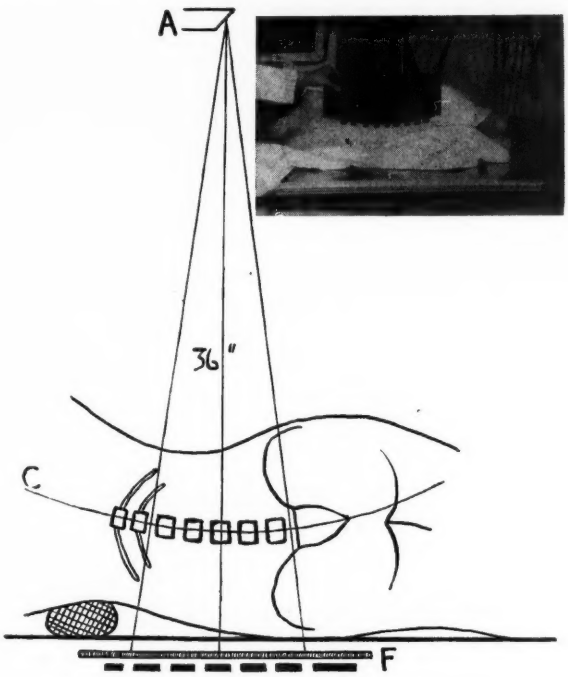


FIG. 317.—To illustrate technique used for lateral radiography of lumbar spine. Sketch illustrating how rays diverging from the anode pass accurately through each intervertebral space when the spine is curved. A, Anode; F, Film; C, Arc of circle of 30-in. radius. *Inset*, Photograph showing patient in position for lateral radiograph. Cardboard pattern corresponds with curve of lumbar spine (marked on skin).

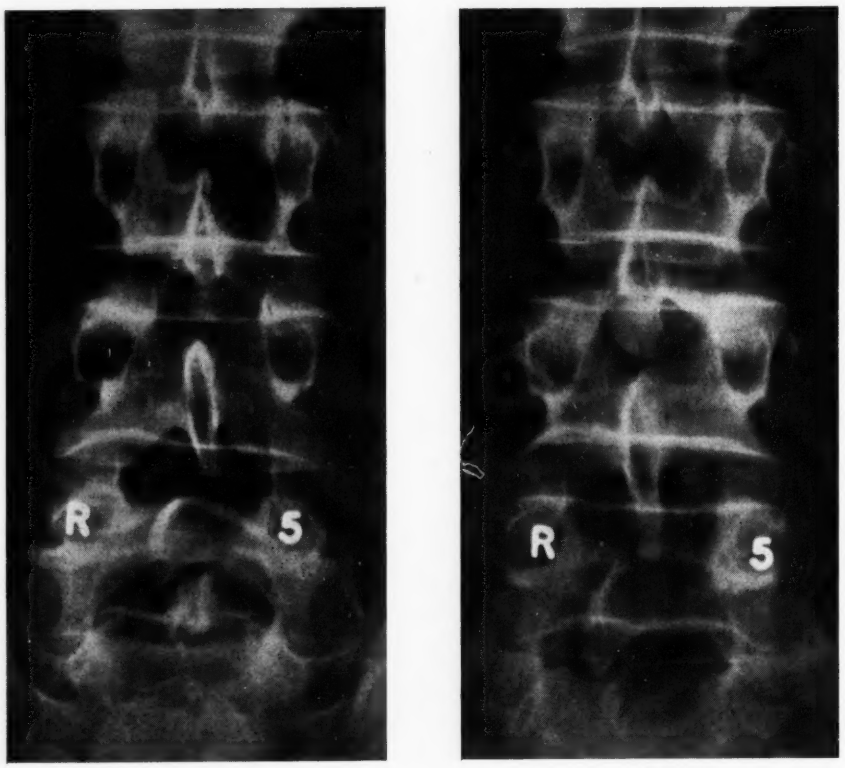
spinal curve is adjusted (if necessary increasing it) by means of cotton-wool bags, until it coincides with the arc of a circle centred on the anode, and the film is exposed. This arc may be readily determined by fixing one end of a piece of string to the position of the anode and marking out the circle on the patient's back in the line of the lumbar spinous processes. It is more convenient, however, to use a cardboard pattern of the arc of the appropriate circle, with which the curve of the spine is made to correspond (*Fig.* 317, *inset*). For a 36-in. anode–film distance, an arc of a circle of 30 in. radius is suitable for the average patient. By this method of positioning the width of all the lumbar interspaces can be accurately shown on a single film (*Fig.* 318).

FIG. 318.—Lateral radiograph of lumbar spine resulting from technique illustrated in *Fig.* 317. All the intervertebral disk spaces and the vertebral bodies are accurately shown by the diverging rays.

Occasionally, when muscular spasm is great and the scoliosis is pronounced, a prone-lateral radiograph gives a truer picture of the disk spaces, for in this position the spinal deformity becomes less marked.

b. Postero-anterior (or Anteroposterior) Projection.—Some patients with symptoms suggesting disk prolapse have a slightly kyphotic lumbar spine (6 per cent in this series), and in them the standard anteroposterior projection gives a satisfactory view of all the lumbar interspaces. In most, however, the normal lordotic curve makes accurate visualization of more than one or two spaces impossible with this projection (*Fig.* 319 A). Also in this projection the superimposition of the lowest lumbar vertebra and the sacrum sometimes obscures significant pathological changes at the lumbosacral level.

A postero-anterior projection is therefore used (*Fig.* 319 B). With the patient prone and the tube centred over the third lumbar vertebra, the lumbar



A B

FIG. 319.—Comparison of radiographs of the same patient, taken with the standard A–P technique (A) and with the P–A technique illustrated in *Fig.* 320. A, A–P projection. Only third space is well shown and inferior margin of fifth vertebra is obscured by shadow of sacrum. B, P–A projection. Each space and all vertebral margins clearly seen.

curve is made to conform as nearly as possible with the same cardboard pattern by means of cotton-wool bags (*Fig.* 320). The phase of respiration during which the exposure is made, is also used to assist in

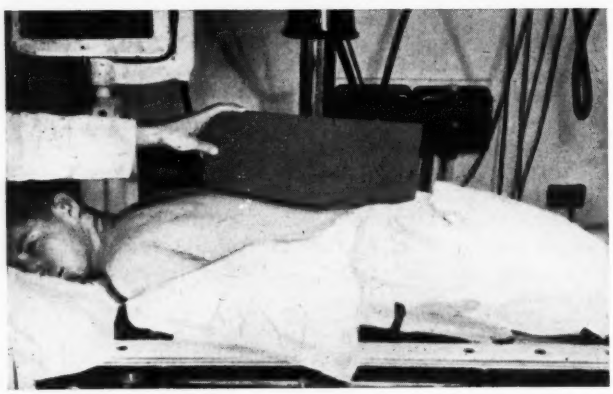


FIG. 320.—Photograph of patient in position for P–A radiograph. In this patient the lordotic curve corresponded on deep respiration with that of the pattern.

producing the correct spinal curve, for the degree of lordosis alters with breathing, being greater on expiration. Should the lumbosacral angle be more marked than usual, the tube may be tilted in either the anteroposterior or postero-anterior projections to give a supplementary view of this area.

Movement Studies.—At a late stage in our investigation a study was also made of the relative amounts of movements occurring between the adjacent lumbar vertebræ. Often abnormalities in the pattern of spinal movement were detected which proved helpful in suggesting the probable level of the protrusion. This form of examination proved of greatest value in those cases where plain radiographs revealed no abnormality, or where signs of disk degeneration were seen at many levels in the lumbar spine.

In the method which we use, lateral views of the lumbar spine are taken both in acute flexion and in acute extension, and by superimposing the radiographs the degree of movement at each interspace is measured.* For this purpose the apparatus seen in *Fig.* 321 has been designed. The patient

* An accurate and rapid method of doing this is as follows: The film taken in extension is placed on a horizontal viewing box, and a sheet of paper is laid over its upper portion and held firmly in this position with a paper-weight or similar object. Next the film taken in flexion is placed on top so that the outlines of the sacrum coincide in both films, and a pencil is drawn along the top margin of the upper film to form a base line on the sheet of paper. Then the upper film is adjusted so that the shadows of the fifth lumbar vertebræ become superimposed, and the pencil is again drawn along the top of the upper film. This process is repeated with the other vertebral bodies. The angles between successive lines indicate the amount of movement taking place at each interspace.

sits on the seat with his legs supported, and his pelvis immobilized by means of an adjustable leather waistband, which is prevented from riding up over the iliac crests by lateral anchoring straps. With the central ray horizontal, lateral radiographs are then exposed in acute flexion (*Fig.* 322 A) and in acute extension (*Fig.* 322 B) of the lumbar spine.

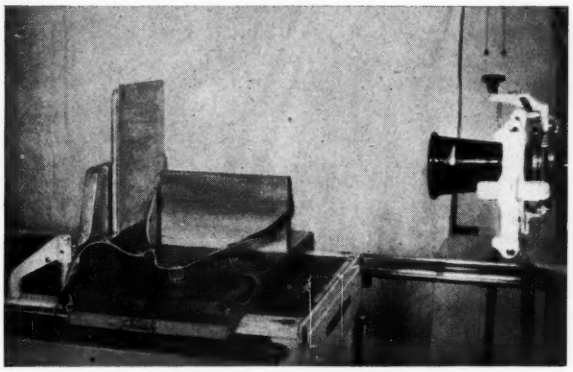
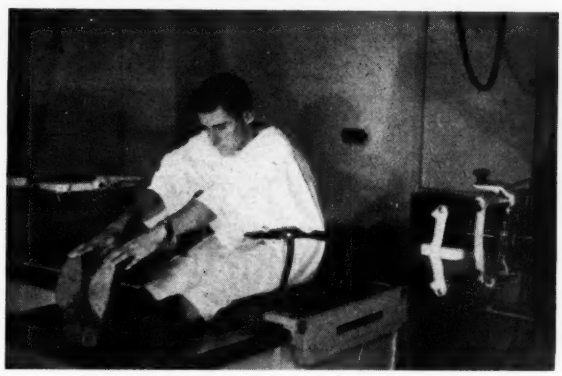


FIG. 321.—Apparatus devised for movement studies of lumbar spine. A wooden seat with a back 6 in. high is fixed to the radiographic table. The film and wafer grid are supported in a slot at right angles to the horizontal rays from the X-ray tube.



A

B

FIG. 322.—Photographs to illustrate method of examination. The pelvis is fixed by means of straps. Films are exposed with the patient in acute flexion (A) and in hyperextension (B) of the lumbar spine.

Knutsson (1944) has employed the same principle, but with the patient standing.

RESULTS AND DISCUSSION

In this series of 100 cases the routine films revealed no abnormality in 18 cases, and evidence of disk degeneration in the lumbar spine in the remaining 82 cases.

Of the 18 patients whose lumbar spines appeared normal, 9 were males (1 in 8 of all males) and 9 females (1 in 3 of all females). The significance of the low incidence of degenerative changes in women is not clear, but is possibly connected with a less strenuous use of the lumbar spine. The average age of these 18 patients was less (30 years) than that of those showing evidence of disk degeneration (35 years), and the duration of symptoms was shorter (varying from 2 months to 17 years, average 3 years 2 months) than in the other group (varying from 2 months to 27 years, average 6 years). In general, therefore, it would appear that, in patients suffering from symptoms of posterior disk prolapse, the lumbar spine is more likely to appear normal in the younger patients, in those with a relatively short history of symptoms, and in the female patients. Although in these patients routine radiography has been of no positive value, movement studies have proved of assistance, and these will be considered later.

The second group, those 82 patients (64 males and 18 females) whose radiographs revealed abnormalities, could be subdivided into two classes; first, those showing degenerative changes at several levels in the lumbar spine (42 patients), and, secondly, those where evidence of degeneration was found predominantly at one disk space (40 patients). In the first subgroup (36 male and 6 female cases) the appearances, although of no localizing value, were helpful in that they indicated that the spine was degenerate, and consequently that a posterior prolapse might be present. Indeed in 13 cases (a third of the subgroup) multiple prolapses were found at operation. In the second subgroup (28 male and 12 female) there were 34 patients in whom evidence of degeneration was confined to one disk space, and 6 in whom minimal changes could be detected in the upper lumbar region in addition to advanced changes at a single lower lumbar interspace. In all these patients a protrusion was later found at operation at the suggested level, although in 3 of them a second prolapse was also found at a radiologically normal interspace. In our 100 patients, therefore, radiological evidence of degeneration of the lumbar intervertebral disks was found in 82, while in 40 the routine radiographs suggested the actual level at which the prolapse was situated.

The various types of appearance noted in the routine radiographs will now be considered in more detail. For convenience each radiological sign will be discussed separately, although often several of them may be found at a single disk space. First will be considered those signs which may be of localizing value, followed by those signs which are without particular localizing significance. Next will be described the various incidental abnormalities, acquired and congenital, which were demonstrated radiologically. Finally will be recorded some

observations concerning alterations in the pattern of spinal movement.

1. RADIOLOGICAL SIGNS IN LUMBAR DISK PROTRUSION

a. Signs of Localizing Value.—

i. *Diminution in the Width of the Intervertebral Space.*—This is the commonest localizing sign and was found in 34 instances (85 per cent) of subgroup with localizing signs. In the absence of developmental defects to account for it, such as sacralization of the lowest lumbar vertebra, it indicates disease or degeneration of the disk (*Fig.* 323).

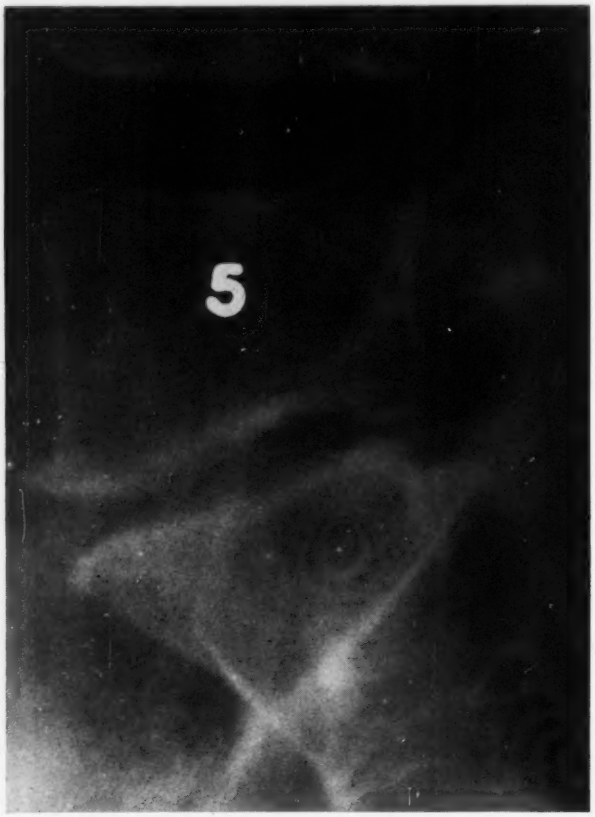
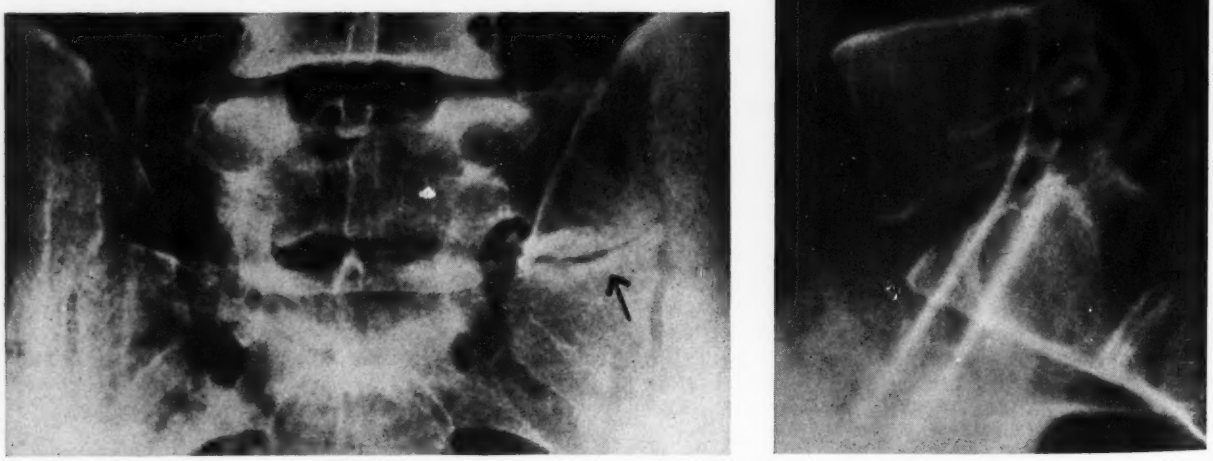


FIG. 323.—Lateral radiograph of lumbosacral junction, showing acquired narrowing of fifth disk with osteophytic outgrowths and sclerosis.

Normally, the disk between the fourth and fifth lumbar vertebræ is the thickest, while those above become successively thinner. The fifth or lumbosacral disk is wedge-shaped and of variable width. This natural variation in the width of the lumbosacral disk makes it difficult to determine, in the absence of hypertrophic changes or sclerosis, whether a thin lumbosacral disk is a congenital feature or one acquired during the degenerative process. It is often possible, however, to deduce from the plain films of each individual patient what the normal width of the fifth intervertebral space should be, for its width is reflected in the bony architecture of this region. Thus if the fifth lumbar vertebra shows signs of sacralization, the space is usually narrow (*Fig.* 324). Such anatomical variations are common, and the relative widths of all the lumbar intervertebral disks alter in conformity with them. In estimating the width of each disk space, it is better to use the neighbouring spaces for comparison than to apply any arbitrary measurements, for the eye can readily appreciate any departure from the normal gradual progression in the width of the interspaces, as seen in a good lateral radiograph (*see Fig.* 318).

The narrowing evident in a pathological disk space varies considerably in degree as well as in character. The degree of narrowing present does not bear any constant relationship to the size of the prolapse, and it is not unusual to find a large



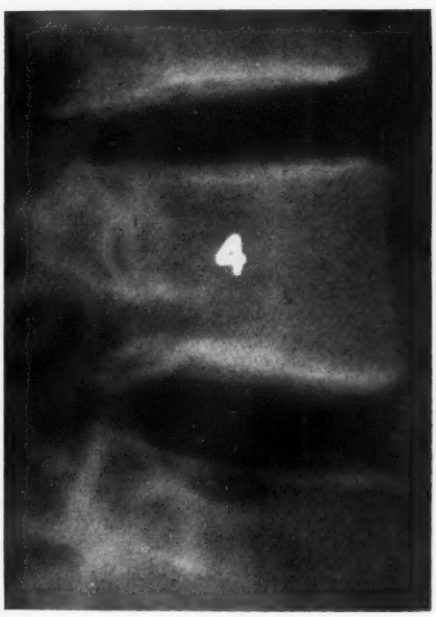
A B

FIG. 324.—Radiographs of lumbosacral junction, showing congenital narrowing of the fifth disk in case of unilateral sacralization. Note articulation of lateral mass of fifth lumbar vertebra with sacrum (*arrow* in A).

protrusion with little diminution in the width of the disk space (*Fig.* 325), or a small prolapse at a greatly narrowed space (*Fig.* 326). In general, however, a considerable narrowing of the interspace, in the absence of osteophytic outgrowths or sclerotic changes indicating an old-standing scarred disk, suggests a large-sized protrusion. The amount of tissue which prolapses is small relative to the volume of the disk itself, and degenerative processes must therefore be responsible for most of the decrease in width of the affected disk. The extent to which an interspace is narrowed by loss of a known amount of disk may be seen in *Fig.* 327, where 4 c.c. of disk substance were removed at operation.

FIG. 325.—Lateral radiograph of lumbar spine taken during myelography with the patient's head down 60°. The fourth space is only moderately narrowed, but a large prolapse caused a complete block of the theca at this level.

FIG. 326.—Lateral radiograph of lumbar spine taken during myelography. Although the fourth space is greatly diminished in width, no evidence of a posterior projection was found during myelography. At operation nerve-roots were adherent to typical 'scarred disk'.



A

B

FIG. 327.—Lateral radiographs of lower lumbar spine. A, Before curettage of disk; B, Three months after operation, at which 4 c.c. of disk substance were removed.

The character of the narrowing also varies. Most often—70 per cent of cases—it affects the disk

evenly, and a generalized diminution in width results (*Fig.* 328); less frequently—11 per cent—the posterior portion of the disk is chiefly involved (*Fig.* 329); and sometimes—19 per cent—its lateral portion (*Fig.* 330). As might be anticipated, the could be demonstrated at the level of the prolapse in 22 cases (55 per cent of the sub-group). These bony changes (*see Fig.* 323) are secondary to a diminution in the width of the disk space with consequent hypermobility of adjacent vertebral bodies (*see Fig.* 345).

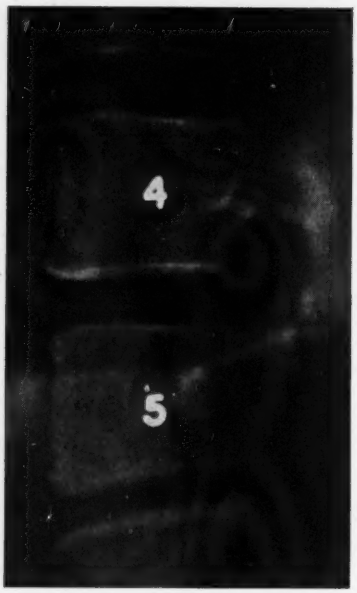


FIG. 328.—Lateral radiograph of lower lumbar spine, showing varying widths of disk spaces. Generalized narrowing at fourth and fifth interspaces with hypertrophic changes at fifth level. Also note parallelism of opposing vertebral surfaces at fifth space. At operation a prolapse was found at both these spaces, that at the fifth space being an extrusion of nucleus pulposus.

FIG. 330.—P–A radiograph, showing narrowing of fourth disk space, most marked on left side, resulting in a localized scoliosis with apex at this level.

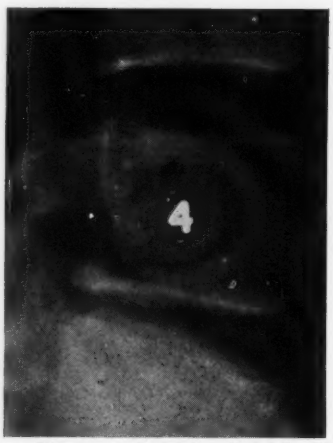
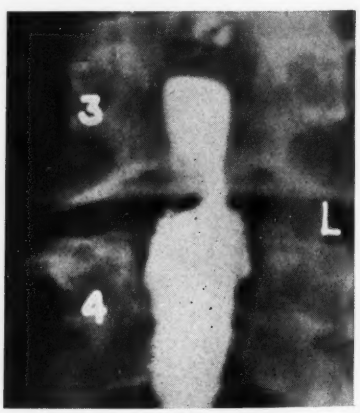


FIG. 329.—Lateral radiograph of lumbar spine, showing narrowing of fourth disk space, most marked posteriorly.

A



B

FIG. 331.—A, Lateral radiograph, showing large osteophyte (*arrow*) projecting posteriorly into spinal canal; B, Myelogram reveals deformity of the thecal column caused by osteophyte.

disk space has shown a general narrowing in cases of extrusion of the nucleus pulposus and in scarred disks (*Figs.* 326, 328). (For classification of disk lesions, *see* Falconer, McGeorge, and Begg, 1948, a). Where the posterior aspect of the disk is chiefly affected, it is likely that degeneration and necrosis of the posterior portion of the annulus, so often found at autopsy by Donohue (1939), is responsible.

ii. *Hypertrophic Changes and Sclerosis of Adjacent Vertebral Bodies.*—Hypertrophic changes localized to the margins of contiguous vertebral bodies A considerable variation occurs both in the extent of this reaction and in the situation where these osteophytes develop. Most frequently they arise from the anterolateral aspects of adjacent vertebral bodies, less often from their anterior margins, and least commonly from their posterior aspects (*Fig.* 331). In the older spines these hypertrophic outgrowths are the rule, and represent the natural method of fixing the mobile vertebral bodies by interlocking bony buttresses in actual ankylosis (*Fig.* 332).

Few data are available to show how quickly these bony outgrowths follow degeneration of the disk, but the time varies considerably in different individuals. Thus in some patients with symptoms of many years' duration no osteophytes may be present, while in others marked changes may be evident radiologically when symptoms are first noticed, suggesting that symptomless degeneration of the disk had been present for a considerable time. Perhaps a typical example of the growth of osteophytes is seen in *Fig.* 333, where the width of the disk space has diminished, and hypertrophic changes have become evident during the five years since symptoms first appeared. The rate of growth of hypertrophic outgrowths may be even more rapid after such gross injury to the disk as the penetration of a bullet (*Fig.* 334), or after dislocation of the spine. Although many exceptions are met, in general osteophytes of large size and vertebral sclerosis indicate degeneration of long standing.

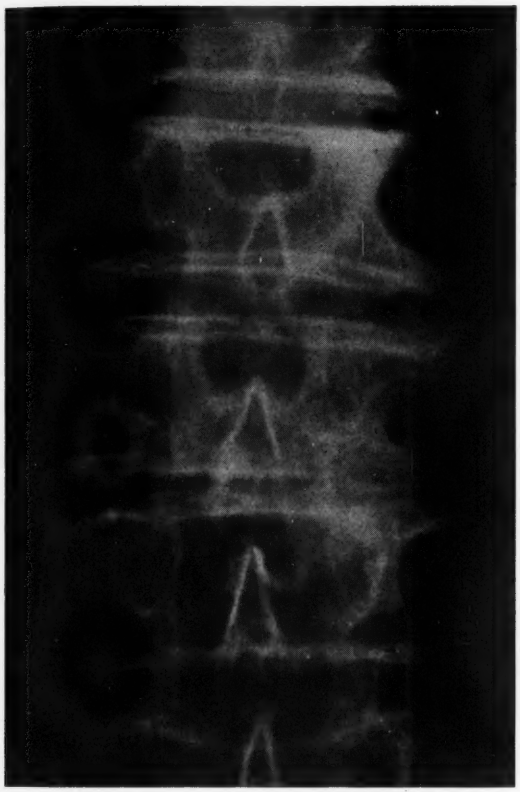
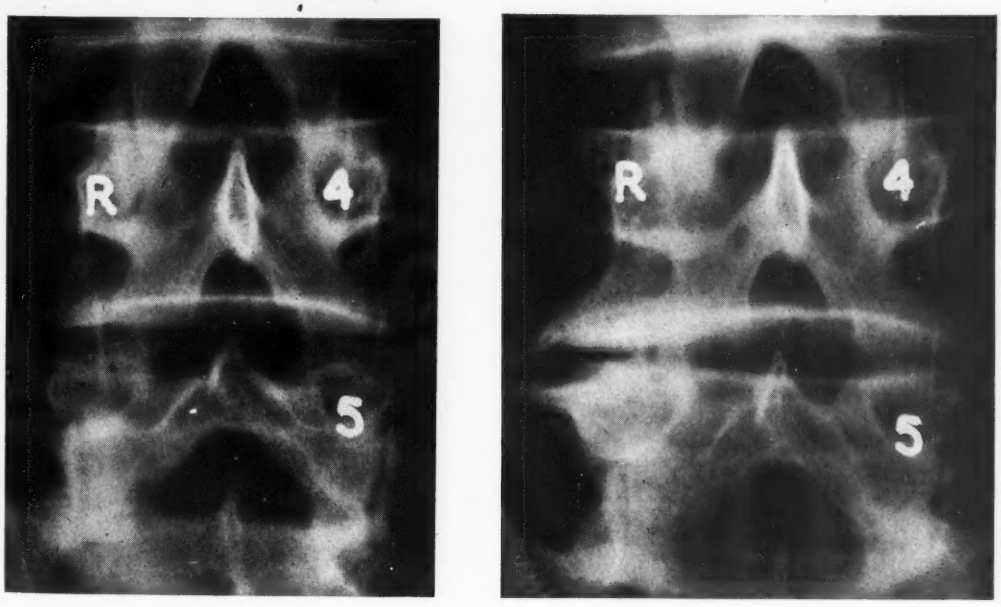


FIG. 332.—P–A radiograph showing large interdigitating osteophytes restoring stability at level of narrowed degenerate disks.

iii. *Localized Scoliosis.*—A localized type of scoliosis (*Fig.* 330) with its apex at the level of the prolapse was found in 9 cases (19 per cent of this subgroup). This appearance, seen most readily in the postero-anterior projection, is due to the narrowing of the affected disk being predominantly on one side, and may be taken as evidence that it is degenerate. The convexity of the scoliosis in these 9 patients was to the right in 7 and towards the left in 2. The lesion was found to be situated on the same side as the convexity of the curve in 5, on the contralateral side in 2, and in the midline in 2 instances. As might be expected seeing that they represent a spontaneous buttressing mechanism, the accompanying osteophytic outgrowths are largest in the concavity of the curve (*Fig.* 333 B).

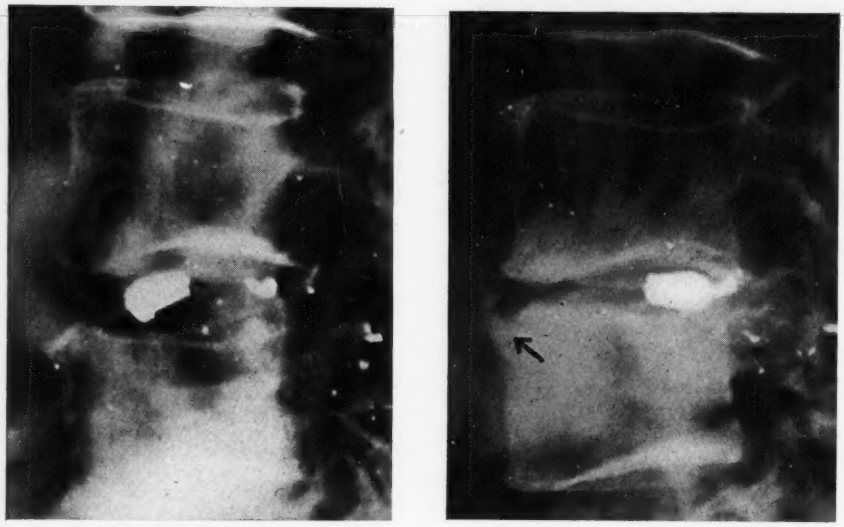
iv. *Relative Displacement of a Vertebral Body.*—Minor displacement of a vertebral body from the normal curve in which it lies is difficult to determine, for slight spinal rotation or inaccurate radiography may give rise to such an appearance. Definite malalinement of a vertebra, however, was seen in 5 cases (12 per cent of the subgroup). If the fifth vertebra



A B

FIG. 333.—P–A radiographs of lower lumbar spine, showing rate of growth of osteophytes at site of disk protrusion. A, Film when sciatica first complained of shows moderate degree of narrowing of fourth interspace (Oct. 4, 1940). B, Film taken five years later shows greater narrowing of disk space and the formation of osteophytic outgrowths—largest in the concavity of scoliosis (Nov. 11, 1945).

is displaced it appears to move backwards (*Fig.* 335), as has recently been confirmed by Knutsson (1944). Accompanying this posterior displacement of the fifth lumbar vertebra on the sacrum is a loss of the normal wedge shape of the lumbosacral disk, with an approximation to parallelism of the opposing bony surfaces, which leads clinically to flattening of the lumbosacral spine. Several factors are probably responsible for this retroposition of the fifth lumbar vertebra, but in at least 3 of the 5 cases in which we have noticed it, a prolapse at the lumbosacral space was present, so that its recognition would seem to be of localizing value. Vertebræ at a higher level may slide either forwards or backwards as the underlying disk degenerates.



A B

FIG. 334.—Radiographs illustrating rate of growth of osteophytes. A, Film later in day of wounding shows bullet lodged in centre of third lumbar disk; B, Film one year later shows narrowing of space with development of osteophytes (*arrow*).

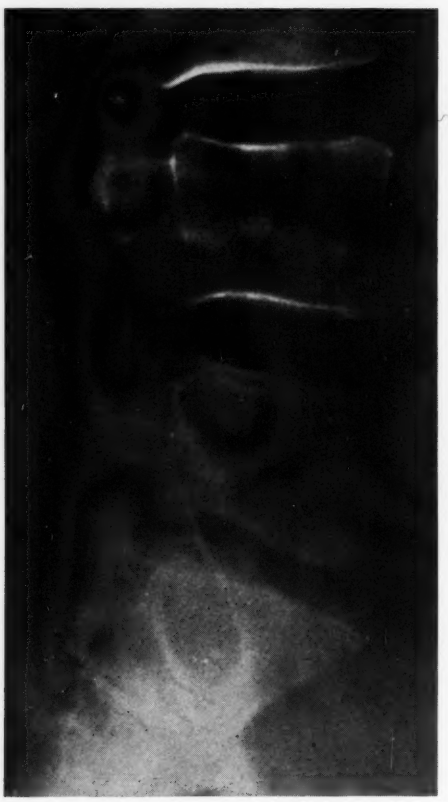


FIG. 335.—Lateral radiograph of lower lumbar spine, showing relative displacement backwards of fifth lumbar body on sacrum, with loss of normal wedge shape of lumbosacral disk. Prolapse of fifth lumbar disk confirmed at operation.

FIG. 336.—Radiograph showing fixed kyphosis of lumbar spine secondary to disk protrusion at lumbosacral disk.

b. Signs of No Localizing Value.—In the other group (42 patients) where evidence of degeneration was found involving many or all of the lumbar disks, the foregoing signs were often present at many spaces, and therefore were of no assistance in localization. In addition, other radiological appearances were noticed, e.g., spinal deformity, multiple Schmorl's nodes, anterior intraspongy nuclear herniations (' persistent epiphyses '), and ' hypertrophy ' of the disks. These will be discussed briefly.

i. *Spinal Deformity.*—The stiff straight spine so often found in cases of disk protrusion is revealed radiologically by a loss of the natural lumbar lordosis. In some cases a definite kyphotic curve is present (*Fig.* 336), and in our experience this is rarely seen with any other lesion. This alteration in the normal spinal curvature is probably a protective mechanism caused by reflex muscle spasm, which may be surprisingly localized, for a disk protrusion may diminish in size on flexion of the spine and then impinge less forcibly on the adjacent nerve-roots (Falconer, McGeorge, and Begg, 1948, a). A lateral spinal curve is also frequently found in some cases, but a generalized scoliosis is of no assistance in localizing the prolapse, or in indicating the side on which a disk lesion is likely to be found.

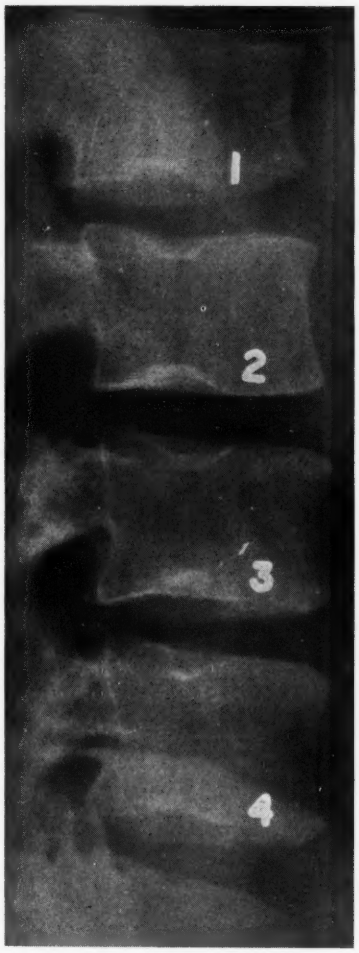


FIG. 337.—Lateral radiograph of spine, showing Schmorl's nodes in contiguous surfaces of the upper four lumbar vertebral bodies.

ii. *Schmorl's Nodes.*—These lesions, which represent nuclear herniations into the spongiosa, can only be detected radiologically after a thin layer of compact bone has been formed around their periphery. When seen they indicate, therefore, degeneration of long standing, but are not associated with posterior disk protrusions. They were found in 8 cases (19 per cent), and were often multiple (*Fig.* 337).

iii. *Anterior Intraspongy Nuclear Herniations.*—These lesions were found in two cases. They are really Schmorl's nodes which occur near the anterior margin of the vertebral body at the junction of centrum and epiphysial ring. They are to be distinguished because in some cases they lead to separation of the anterior margin of the vertebral body, a condition often referred to as a ' persistent epiphysis ' (*Fig.* 338).

FIG. 338.—Lateral radiograph of spine, showing anterior intraspongy nuclear herniations of the L.4 and L.5 bodies. In the fourth lumbar vertebra only has a ' persistent epiphysis ' developed.

iv. ' *Hypertrophy* ' *or* ' *Ballooning* ' *of the Disks.*—This appearance, seen in 6 of our patients, is not evidence of disk degeneration, but is secondary to malacic changes in the vertebral bodies.

2. INCIDENTAL CONDITIONS FOUND ASSOCIATED WITH LUMBAR DISK PROTRUSION

Various incidental abnormalities both congenital and acquired were discovered in the routine radiographs. Although these conditions appear to have no direct relationship with the disk protrusion, the recognition of some of them seems helpful in suggesting the level at which the prolapse is likely to be found.

a. Sacralization.—Sacralization of the fifth lumbar vertebra was present in 9 instances. In 5 it was bilateral, though usually asymmetrical; in 4 it was unilateral, three times on the right side and once on the left. This evidence of sacralization, however, is no more frequent than that reported by others studying radiographs of unselected groups of patients (Doub, 1925; Brailsford, 1929) and of anatomical specimens (Willis, 1924). Sacralization, therefore, does not appear to predispose patients to disk protrusion.

In each patient, however, in whom sacralization was found, the accompanying protrusion involved the disk immediately cephalic to the sacralized segment. The constancy of this finding makes it possible to state with some assurance that in cases

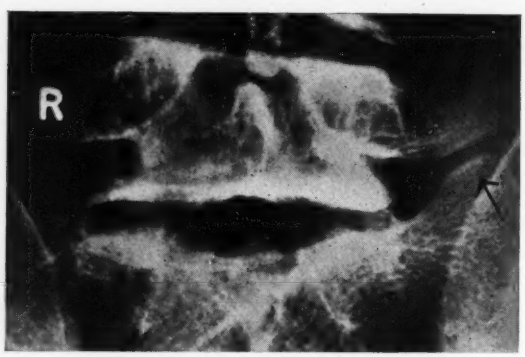


FIG. 339.—P–A radiograph of lumbosacral junction, showing lateral wedging of L.5 vertebral body. The resulting scoliosis has caused a transverse process of average size to impinge upon the sacrum, forming a diarthrodial joint (*arrow*). A disk prolapse was present at the lumbosacral disk on this side.

where the clinical features suggest disk protrusion and radiological examination demonstrates sacralization of the fifth lumbar vertebra the prolapse will be found at the fourth disk space. It seems likely that the narrow lumbosacral disk is protected by the sacralizing process, and consequently cannot prolapse. The fourth disk, therefore, alone remains as the site of a disk prolapse likely to cause sciatic pain.

b. Defect in the Pars Interarticularis of the Neural Arch.—A defect in the pars interarticularis of the neural arch is the predisposing cause of spondylolisthesis, and was seen in the radiographs of 3 of our patients, although others may also have had it, for it may be impossible to demonstrate this condition radiologically (Brailsford, 1929). Willis (1924) found this defect to be present in 5·2 per cent of 1520 anatomical specimens, and therefore it by itself probably does not cause symptoms or disk prolapse. But if spondylolisthesis supervenes, then disk prolapse may also result at the disk which is thereby disorganized.

c. Spina Bifida Occulta.—This condition was observed radiologically in 5 patients—in one it affected the fifth lumbar lamina, in the others the first and second segments of the sacrum. As Brailsford (1929) noted spina bifida in 11 per cent of more than 3000 routine radiographs, the incidence of spina bifida in our series does not support the contention of many authorities (Meyerding, 1938; Millwee, 1939; Gillespie, 1946) that this fusion defect weakens the stability of the spinal column or predisposes to injury, deformity, or disk protrusion.

d. Lateral Wedging of the Fifth Lumbar Vertebra.—In 2 cases the body of the fifth lumbar vertebra was narrowed on one side, resulting in a scoliotic deformity. In one instance (*Fig.* 339) the wedging was such that a normal transverse process impinged upon the sacrum, resulting in a diarthrodial joint. In both patients the lumbosacral disk had prolapsed, and in one an additional protrusion was found at the fourth space. It is reasonable to presume that the scoliosis produced by this developmental anomaly and the friction between the transverse process and the sacrum during spinal movements had caused abnormal and irregular stresses, encouraging degeneration and prolapse of these disks.

e. Interarticular Arthritis.—Diminution in the width of the intervertebral space causes an increased burden to fall on the interarticular joints, which might therefore be expected to show evidence of arthritic changes. Such changes were found in only 1 case, although, had oblique views been taken as a routine, evidence of this condition might have been discovered more often.

f. Sacro-iliac and Lumbosacral Arthritis.—In one patient with a prolapse at the fourth space and left-sided symptoms, radiological changes characteristic of 'arthritis' were present in the right sacro-iliac joint. In another patient also with a left-sided prolapse at the fourth space, arthritic changes were seen in the lumbosacral joint in conjunction with a right-sided sacralization of the fifth lumbar vertebra. These lesions are probably incidental, although in the past symptoms originating from a disk protrusion have been attributed to arthritic changes in these joints.

g. Associated Compression Fractures.—In 3 cases healed compression fracture of the first lumbar vertebra was apparent, while in 1 patient a transverse process had been fractured. These findings probably signify nothing more than that the spine has been subjected to violent trauma, as all these fractures were remote from the level of the disk protrusion responsible for symptoms. Similar findings have been reported by Camp (1937), who found compression fractures at a distance from the site of prolapse in 3 out of 50 cases.

3. ABNORMAL PATTERN OF SPINAL MOVEMENT IN LUMBAR DISK PROTRUSION

Although a general impression of the movements of the spine may be obtained from clinical examination, radiography affords the only method of investigating the movements at each individual intervertebral disk. By comparing lateral radiographs taken in full flexion and in full extension (*see Fig.* 322), it has been possible to study the movement of the lumbar spine at each intervertebral disk (*see* "Method of Examination").

In the average person about 70° of movement occurs in the lumbar spine between full flexion and full extension, of which some 45–50° takes place at the lowest three intervertebral spaces. The degree

of movement at each disk space is usually greatest at the lumbosacral disk, but alters with the size of this variable disk, while above this level it decreases progressively (*Fig.* 340). In full flexion a slight kyphos appears with the curve centred about the anterior margin of the third intervertebral disk. In full extension a considerable lordosis develops, but this curve does not form the arc of a circle, but instead is parabolic. The natural movement taking place at each individual disk is modified and influenced by pathological conditions arising both within

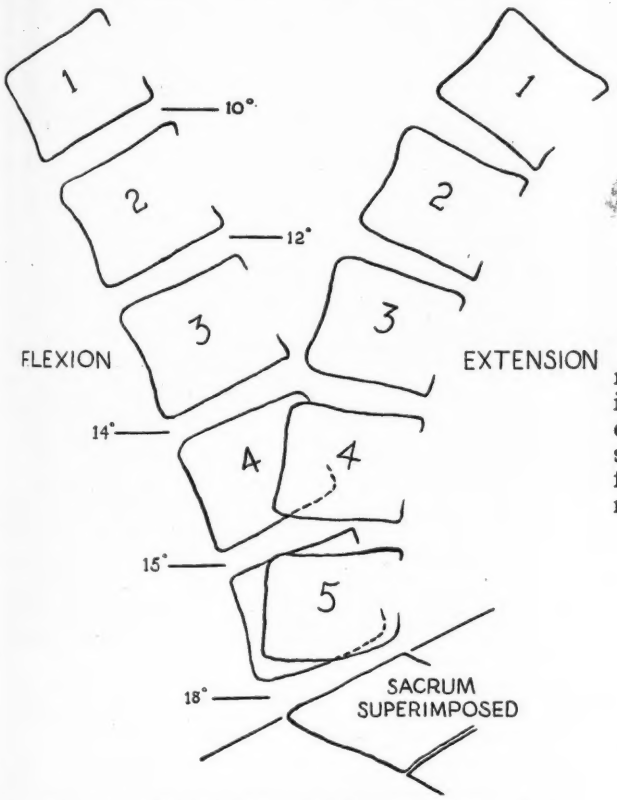


FIG. 340.—Tracings of lateral radiographs of the lumbar spine in full flexion and in full extension, showing normal pattern of movement. The amount of movement at each intervertebral disk is indicated.

and without the spinal column. Degenerative changes in the intervertebral disks are a common cause of abnormal movements, either increased or restricted. Increased mobility is seen in the earlier and uncomplicated stages of degeneration (*Figs.* 341, 342), but when the degenerated disk is causing symptoms, as by root-pressure from a protrusion, movement at this level becomes limited by spasm of the paravertebral muscles. Further, when the disk becomes scarred or after curettage, the movement becomes reduced as ankylosis takes place (*Fig.* 343).

Movement studies were carried out in few of the 100 patients who form the basis of our main studies, but since then others have been investigated in this way. Some indication of the value of this procedure may be gained from a correlation with the operative findings in 10 consecutive cases (15 disk prolapses) treated surgically. In all except one case an abnormal pattern of movement was found. In 7 cases (11 prolapses) there was a relative limitation of movement at the level of the protrusion, as in *Fig.* 344. In 3 of these the routine radiographs had

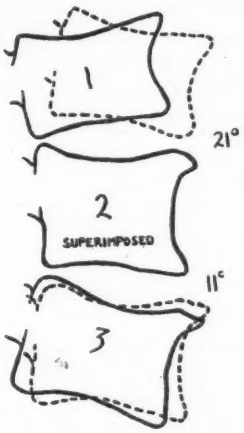


FIG. 341.—Tracings of films taken in full extension (continuous line) and in full flexion (dotted line) of the lumbar spine. In this patient hypermobility was present at first lumbar disk, the result of early degenerative changes. Movement at the second space was normal.

revealed evidence of disk degeneration at many levels in the lumbar region, while in 1 no abnormality was detected. In these 4 cases, therefore, movement studies afforded localizing evidence not obtainable from the routine examination. In one case movement was restricted at a fifth disk of normal size,

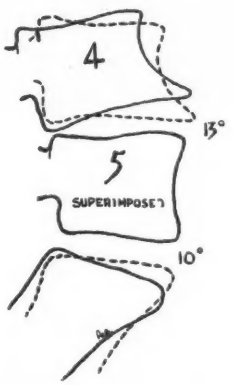


FIG. 342.—Tracings from movement films, showing an increased range of movement at a grossly degenerative disk. (Dotted line, tracing in flexion; continuous line, tracing in extension.)

but was normal at a grossly narrowed and degenerate fourth disk. At operation, however, the fifth disk seemed normal, while a fifth lumbar nerve-root was found adherent to the posterior surface of the scarred fourth disk. It may be significant that this patient's symptoms were little relieved by operation. In another instance (*Fig.* 345) limitation of movement was demonstrated at both the fourth and fifth intervertebral space, and at operation a large midline protrusion was found at the fourth space, but the fifth disk appeared normal. In the remaining case, where the pattern of movement seemed normal, an intermittent prolapse ('concealed disk' of Dandy, 1941) was found at operation at both the lowest interspaces, and subsequent to operation the patient

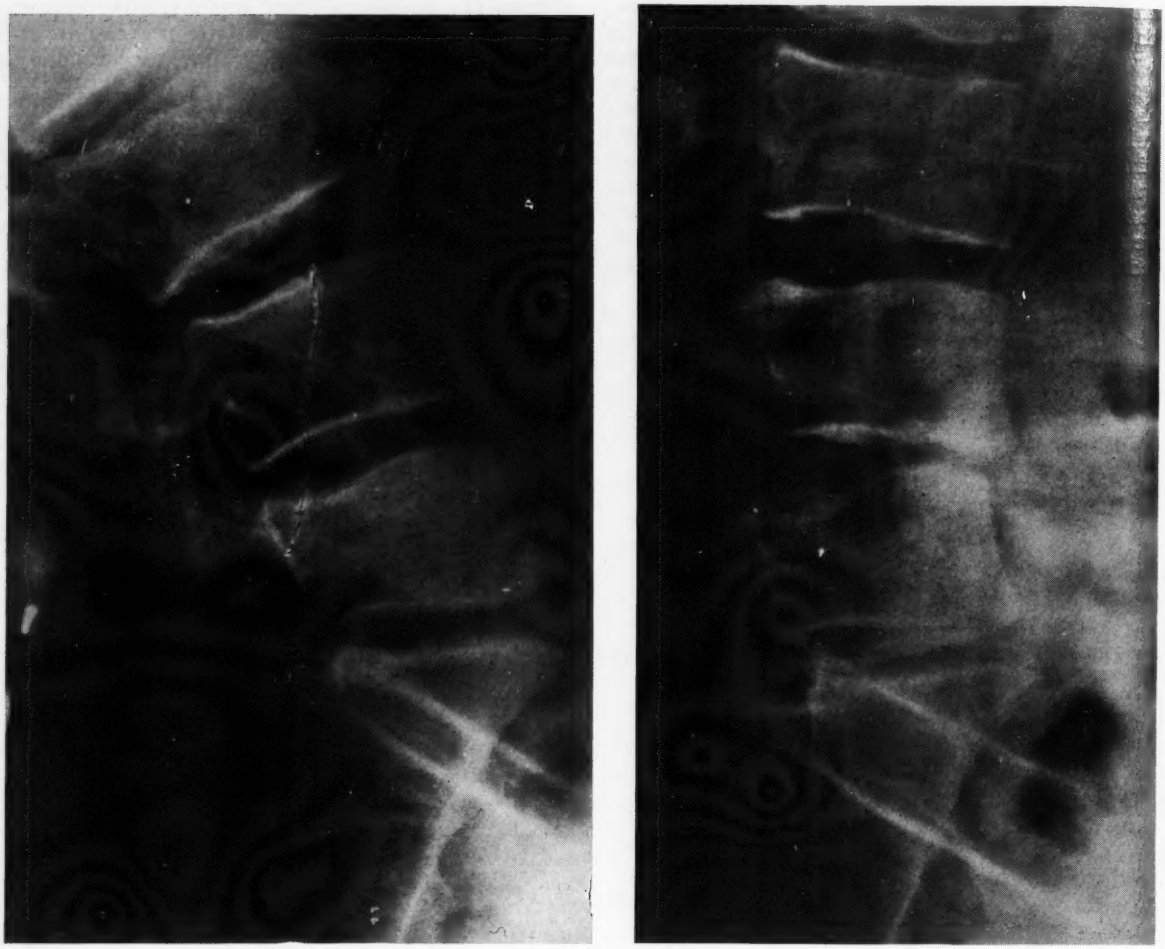


FIG. 343.—Radiographs showing movements in patient with recurrent backache taken one year after operative curettage of fourth and fifth lumbar disk spaces. Note limitation of movement at fifth lumbar disk space, which is presumably becoming ankylosed. Note also hypermobility at fourth lumbar disk, with forward displacement of fourth lumbar body on flexion (B). At subsequent operation further degenerated tissue curetted from fourth disk space.

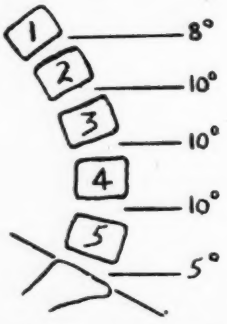


FIG. 344.—Diagram of pattern of spinal movement, showing relative restriction at lumbosacral level where a protrusion was found subsequently at operation.

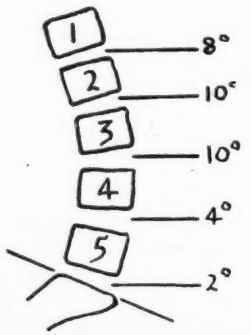


FIG. 345.—Diagram of movement study, showing relative limitation of movement at L.4 and L.5 disks. At operation prolapse found at L.4 only—the fifth disk appeared scarred.

was benefited. The method therefore is helpful in most cases, but not in all.

Most patients with symptoms of lumbar disk protrusion have a rigid lumbar spine, although in some the total amount of movement may still be greater than normal (*Fig.* 346). The mobility of the spine also varies in each patient from day to day with the severity of the symptoms. Absolute angular measurements for each interspace have, therefore, proved of little value. The significant finding appears to be a relative limitation of movement at the disk which is the site of protrusion. There is little doubt that the limitation of movement is due to a protective spasm of the paravertebral muscles splinting the affected disk, thereby shielding the extrathecal nerve-roots from further pressure and the angulating strains which cause sciatic pain (Falconer, McGeorge, and Begg, 1948, b). If

movement studies are carried out after symptoms have subsided, or after the offending protrusion has been dealt with surgically, the pattern of movement often returns to normal, so that, to be of greatest value, this investigation should be carried out while symptoms are present.

This supplementary investigation of the movements taking place between adjacent vertebral bodies would appear worth while, for by this means it has often been found possible to adduce confirmatory evidence of the presence of a disk protrusion, and to predict the level at which this has occurred.

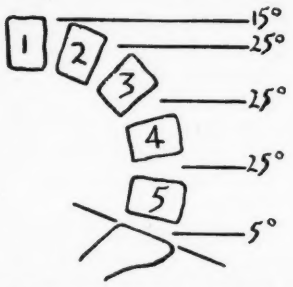


FIG. 346.—Movement study in acrobatic dancer shows a total angular motion greater than normal (95°) in spite of considerable limitation at lumbosacral disk, where a prolapse was found at operation.

SUMMARY AND CONCLUSIONS

It is often possible to deduce the probable situation of a disk protrusion from alterations in the width of the intervertebral space, from changes in the adjacent vertebral bodies, or from any abnormality in the pattern of spinal movement. Prolapse almost invariably occurs in a disk already degenerate.

Plain radiography also may reveal the presence of other conditions which may cause symptoms clinically indistinguishable from those due to disk prolapse, for example, tumours and tuberculous disease of the spine. It may also reveal a number of conditions, acquired and congenital, which formerly were considered to be the cause of symptoms, but which are really concomitant or incidental. Thus the incidence of sacralization is no greater in cases of disk protrusion than is usual, but the detection of this condition is of localizing value, for the affected disk is usually the one cephalic to the transitional vertebra. On the other hand such conditions as spina bifida occulta, and sacro-iliac and interarticular arthritis, are usually fortuitous.

In this series of patients submitted to operation for disk protrusion the lumbar spine seemed normal on routine radiography in one out of five cases. A normal spine occurs three times as often in females as in males, and indeed no abnormality can be detected in the plain films in one-third of women patients.

In four out of five patients with lumbar disk protrusion, radiological evidence of degeneration is found at one or more of the lumbar disk spaces. In half of these patients degenerative changes occur predominantly at one disk space, and it is therefore possible to deduce correctly from the plain films alone the level of the prolapse in two out of every five patients. The two most important signs of localizing value are a relative diminution in the width of the intervertebral space and the presence of localized marginal hypertrophic outgrowths of the adjacent bodies.

When plain radiography is supplemented by movement studies, the site of the protrusion may be deduced in a greater percentage of cases.

It may be concluded that plain radiography, supplemented where necessary by movement studies, should be carried out in every case suspected clinically of lumbar disk protrusion, for by this means useful information may be obtained regarding :—

1. The general configuration of the lumbar and sacral region.
2. The presence of acquired or congenital lesions affecting the bones or the joints in this area.
3. The presence of other conditions which may simulate a disk protrusion.
4. The level at which the prolapse is likely to be found.

We wish to thank Dr. William Sowerby, Chief of the Department of Diagnostic Radiology at the Dunedin Hospital, for facilities for this investigation, and those physicians and surgeons who have referred their patients to us. The technical assistance of members of the Staff of the Radiological Department is gratefully acknowledged.

We are indebted to the Medical Research Council of New Zealand for defraying the expenses of publication of this paper.

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THOROTRAST PYOGRAMS IN CEREBRAL ABSCESS*

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WE have used the term 'pyogram' (literally, a picture or outline pertaining to pus) to describe the radiographs produced after instillation of thorotrast into cerebral abscesses. This method of radiographic control is widely used, and the credit for its introduction goes to Kahn (1939, 1942, 1943), although Freeman (1936) on the experience of one case discussed its possible advantages. Little has been written about the detailed appearances of thorotrast pyograms, although Cairns (1941), Northfield (1942), and Pennybacker (1945, 1948) point out the value of the method.†

In this paper we report on 56 cases of intracranial abscesses in which pyographic studies have been made (*Table I*). Our purpose is, first, to describe the appearances in some detail, and, secondly, to discuss the value of pyography.

Table I.—ABSCESSES IN WHICH PYOGRAMS WERE MADE

CAUSE OF ABSCESS	NO. OF CASES	NO. OF DEATHS
Direct spread:		
Otogenic:		
Cerebral	13	2
Cerebellar	9	2
Paranasal sinusitis	13	2
Osteomyelitis of vault	3	0
Post-traumatic (following compound injuries):		
Penetrating brain	5	2
Anterior fossa fractures	2	0
Metastatic	9	7
Post-operative infection	2	1
TOTAL	56	16

In the Nuffield Department of Surgery, when a brain abscess is suspected it is usually explored in the first instance by a brain needle. If sufficient pus is withdrawn to relieve the patient's symptoms for the time being the abscess is treated by repeated aspirations until the capsule is firm, and then the abscess is completely excised through an osteoplastic flap, unless excision is likely to do irreparable functional damage. In practice this reservation applies almost only to the Rolandic region; in removal of abscess of the temporal lobe preservation of speech usually presents no difficulty; and in removal of cerebellar abscess the cranial nerves and the dentate nucleus can usually be preserved.

In this series, when the abscess was emptied by aspirations, 2 c.c. of thorotrast was injected and radiographs were taken at frequent intervals. From the pyograms thus obtained the progress of the abscess was visualized. Immediately after injection the pyograms show the thorotrast as an ill-defined shadow of irregular shape and density inside the abscess cavity. Within a few days the thorotrast is taken up by the histiocytes of the abscess wall (*Fig.* 347) where it remains permanently. According to Falconer, McFarlan, and Russell (1943) it may stimulate capsule formation.

At any stage in the life-history of a brain abscess pyograms are valuable. The first pictures always indicate precisely the localization of the lesion and its relation to the burr hole through which it was tapped. The size of the shadow can be accurately measured and subsequent radiographs at frequent intervals will show if the abscess is increasing in size and requires to be tapped again. As clinical signs of an enlarging abscess may be dangerously late in appearing, repeated pyograms are of great value in day-to-day diagnosis of the course of the abscess.

When the acute phase of an abscess is passed the decision as to ultimate excision or not rests almostly entirely on the pyograms. Where the shadow rapidly shrinks and there is clinical improvement the removal of the 'scar' is a matter of individual choice, although the exact site of the lesion in relation to the motor or other vital functional areas may be a deciding factor. If it is decided that the abscess should be excised, the appearance of the capsular shadow in the pyograms, which shows a progressive thickening with time, will indicate the appropriate time for operation. We believe that as a general rule there is a definite relationship between this thickness and the age of the abscess.

Further, the presence of other loculi, even when not outlined by thorotrast, can be foretold from the pyograms. In many cases, too, the focus of infection which gave rise to the abscess may be indicated. Good pyograms require good radiographs, and the use of a standardized radiological technique to produce comparable pictures is essential.

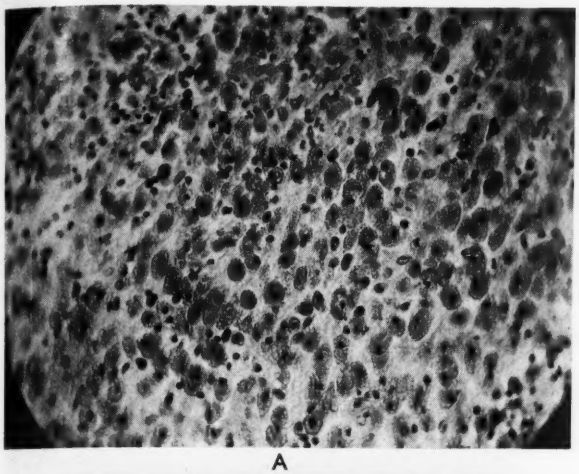
Pyography has been used in slightly more than half the cases of brain abscess in this clinic. The cases in which it was not employed were those in which the abscess was treated by immediate surgical excision.

TECHNIQUE

When the cannula is thought to be correctly sited in the abscess it is held firmly by the operator with his hand steadied on the patient's head, and it is never moved again until it is withdrawn. Pus is removed slowly; if under pressure it is first allowed to drip into a receiver and only later is it aspirated. Slow reduction of tension is important, because rapid

* Read before the Society of British Neurological Surgeons, November, 1947.

† Since this paper was written our attention has been drawn to a paper by E. Tolosa of Barcelona on the diagnostic use of thorotrast in cases of cerebral abscess, read at the meeting of the Scandinavian Neurosurgical Society, in Oslo, in 1947.



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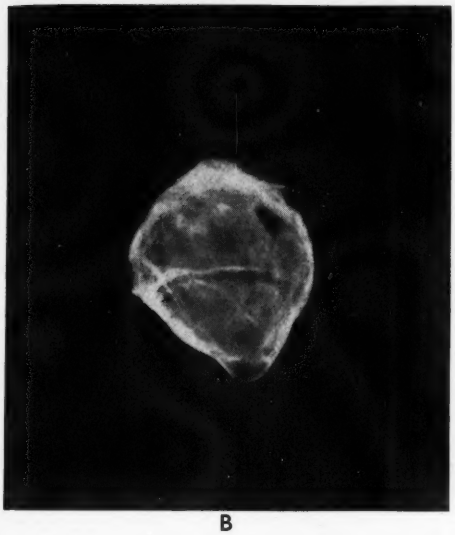

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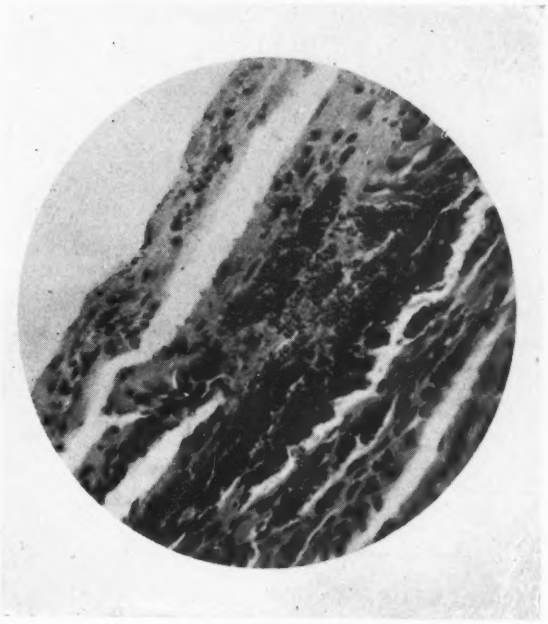


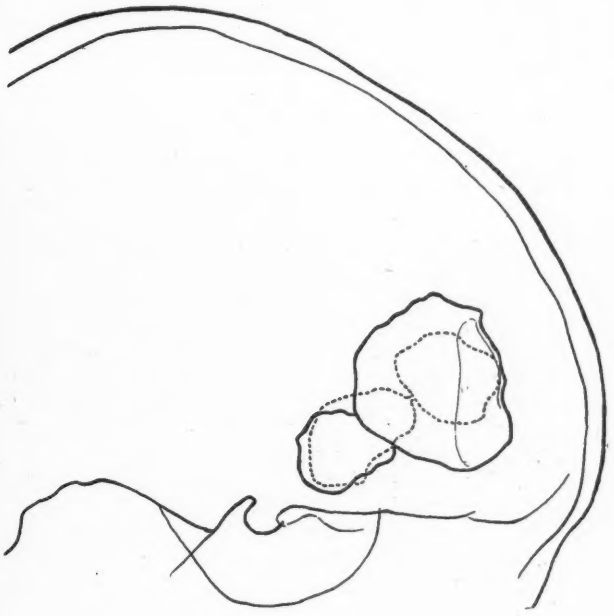
C

FIG. 347.—A, *Early abscess.* Microphotograph of section through the medial part of the wall of an early abscess following the instillation of thorotrast ten days previously. The latter is taken up by the histiocytes and appears as refractile granules. Note the absence of fibroblasts.

B, *Chronic abscess.* A radiograph of the chronic abscess—depicted serially in *Fig.* 351. This picture was taken two years after excision of the abscess, when fluid pus was removed and the capsule hardened in formalin. The opaque shadow is due to thorotrast deposited in the capsule.

C, Microphotograph through the abscess wall, which was 2 mm. thick. The thorotrast was first injected into the cavity seven weeks before removal. The section is cut through the outer part of the capsule (the cavity of the abscess lies to the right). Note the refractility of the granules and the presence of fibrous tissue in the outermost layers of the capsule.

A



B

FIG. 348.—(R.I.12187.)

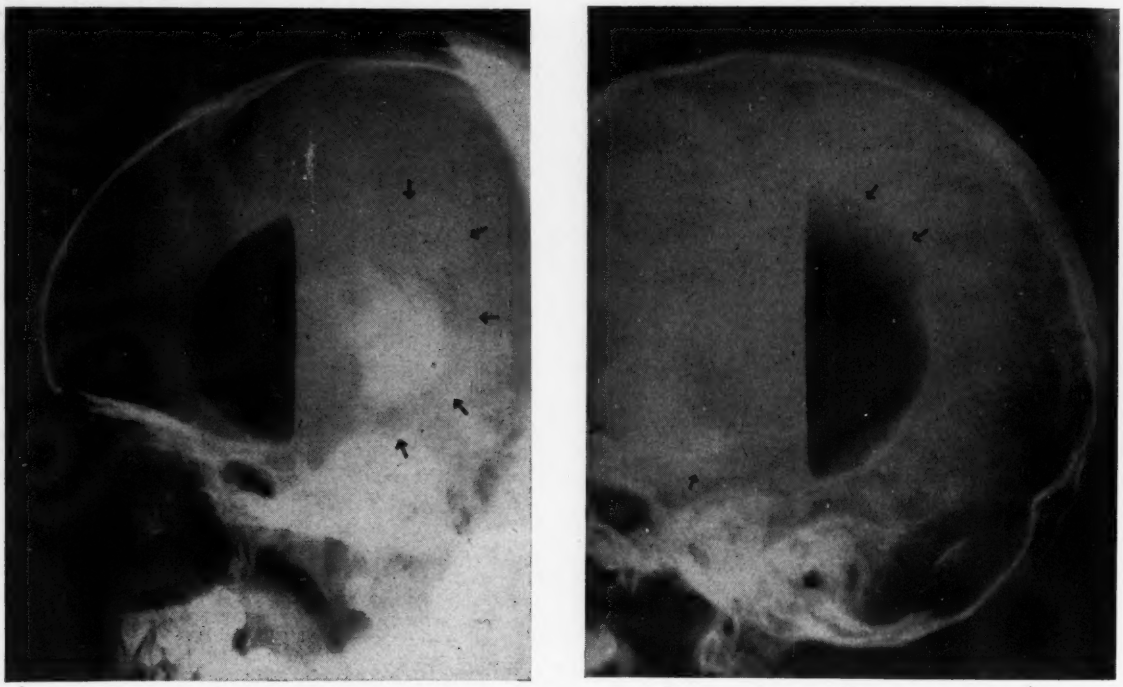
A, A bilocular frontal abscess in a child, following a penetrating frontal wound. The air bubble in the anterior loculus throws into relief the thorotrast lying in the wall of the abscess.

B, Line drawing of the same abscess (continuous line), and the appearance one month later (dotted line) following two aspirations of pus. Whilst the anterior loculus has become smaller the posterior or secondary loculus remains about the same size. Further, the anterior loculus has shrunk down towards a point on its anterior surface which lies directly under the site of the wound. The posterior loculus has tended to follow this contraction, but has not significantly altered in size. The isthmus connecting the two loculi is shown.

decompression may cause bleeding into the abscess cavity. After aspiration a mixture of the appropriate antibiotic (penicillin or streptomycin) and 2 c.c. of thorotrast is injected through the cannula. Thorotrast has no inhibiting action on penicillin or streptomycin *in vitro* (Vollum, 1947). Usually a little air also is sucked into the abscess cavity; if not we believe that it is advantageous to inject 2 c.c. of air at subsequent aspirations, to help in defining the capsular shadow and in measuring its thickness (*Figs.* 348, 350).

352). The anteroposterior, postero-anterior, and half-axial projections demonstrate the position of the abscess in the brain substance and its depth and breadth; also tracks and loculi which may not be apparent in the lateral projections. In cerebellar abscess the half-axial projections show the abscess much more clearly than the anteroposterior projections (*Fig.* 350).

The movements of the head required for these various projections may be useful in mixing the penicillin or other antibiotic with the pus and ensuring



A B

FIG. 349.—(R.I. 72646/47.) *A very large left temporal abscess (streptococcal) in a child, following mastoiditis (to show the value of positioning).* The thorotrast appears to have formed a semi-solid aggregate which moves with the position of the head. A, In the brow-up position an ill-defined linear shadow lies behind the main clump of thorotrast; B, In the brow-down position the air outlines this shadow, which is the posterior part of the capsule—the thorotrast has moved forward. The upward extent of the abscess is also seen to be much greater than is suggested by the brow-up position.

A Lysholm table permits full radiographic examination to be undertaken with the minimum discomfort to the patient, and allows the various projections to be reproduced accurately at subsequent examinations. After study of this series of cases we believe the following projections are required to visualize an abscess in all planes, and to demonstrate loculi and tracks:—

A. With the patient supine:—
1. Anteroposterior.
2. Half axial.
3. Lateral in the brow-up position.

B. With the patient prone:—
1. Postero-anterior.
2. Reverse half-axial.
3. Lateral in the brow-down position.

C. Right or left lateral projection, depending on the side of the abscess.

The lateral projections in the brow-up and brow-down positions are particularly important, as the thorotrast sinks to the lowest part of the abscess, while the air rises to its highest part (*Figs.* 349, that it gets to all parts of the capsule; and certainly they assist in distributing the thorotrast and thus filling adequately any loculi that are present. So often when very few projections have been taken loculi have only been feebly outlined.

After four days, or earlier if the patient's condition is deteriorating, re-examination is undertaken. Four days are necessary to allow the thorotrast to diffuse through the abscess and to define the capsule; but in recent acute abscesses longer may be required. Thereafter routine examinations are carried out at weekly intervals, but, if the patient's condition deteriorates at any time, an immediate examination is made to determine if the abscess is increasing in size. At the re-examinations the number of projections is reduced to those which have best shown the extent of the abscess at the original examination. Usually three projections are sufficient: an axial and laterals in prone and supine positions.

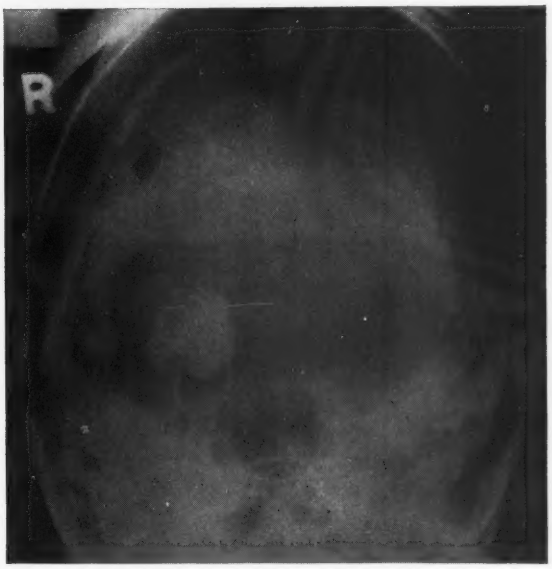
Further thorotrast is only inserted when the abscess is retapped if the amount present has been deemed insufficient at the previous pyography.

In this series the usual number of thorotrast injections was two. If the X-ray pictures have shown the original burr hole badly sited, a fresh one is made (*Fig.* 358). If previous aspirations of the abscess have been difficult the needle can be passed under X-ray control, pictures being taken in two planes (*Fig.* 358); but with experience and care this procedure is rarely necessary.

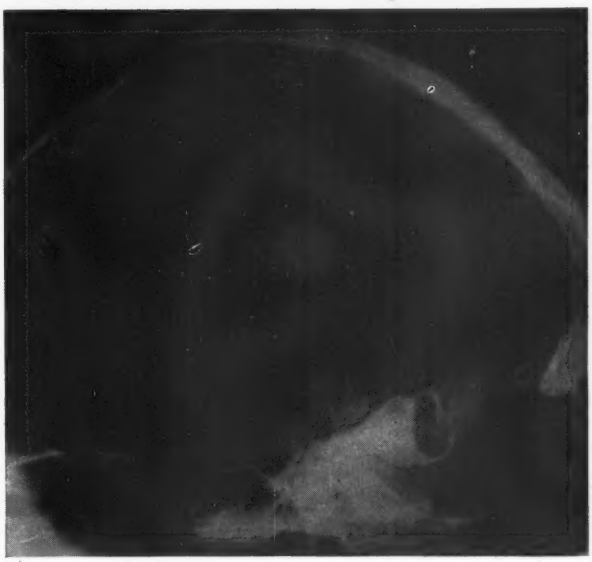
All comparative measurements of abscess size are made with callipers from similar projections.

of headache, meningitis, or focal neurological signs was in retrospect the earliest clinical evidence of intracranial mischief and was taken as the date of onset. In these cases thorotrast was first injected between 6 and 43 days after the onset of the abscess. A capsular shadow of 1 mm. width, as measured directly with callipers on the X-ray films, was usually not observed until the abscess was 35 to 42 days old, no matter how early the thorotrast had been injected.

A



B



C

FIG. 350.—(R.I. 36942/46.) *A cerebellar abscess of otogenic origin.* A and B demonstrate the value of the half-axial projection. The second loculus is not visible in the postero-anterior view, but is clearly seen in the half-axial (Towne) view. C is a lateral view of the same abscess and shows: 1, Air outlining the capsular shadow, which is just over 2 mm. thick; 2, The broad-based fistulous attachment of the abscess to the posterior surface of the petrous bone; 3, Increased opacity of the mastoid air cells—due to leakage of thorotrast from the abscess into the middle ear.

APPEARANCE OF PYOGRAMS

There are certain appearances which are common to all types of abscess and some which will be more conveniently considered under abscesses of different sites and types.

a. Early Appearances.—At the first X-ray examination, immediately after the first injection of thorotrast, the shadow is irregular in outline and density (*Fig.* 351), and some of the thorotrast appears as clumps which move with varying positions of the head. Subsequently a portion of the thorotrast is taken up by the capsule and outlines the abscess wall. The time taken in this process varies according to the age of the abscess when thorotrast is first injected.

In 35 cases an attempt was made to determine the age of the abscess clinically. This is probably impossible to do accurately—except perhaps, in the case of penetrating wounds. However, in these 35 cases an event in the history, such as a fit, onset

In the abscesses of 30 days or older at the time of injection the capsular shadow was usually seen within 4 days; in abscesses 28 days old or less at the time of injection the capsular shadow appeared between 6 and 35 days after injection; though in one exception, an abscess injected at the twenty-third day, the capsular shadow could be seen on

the twenty-sixth day. In this case the evidence of age of the abscess is unimpeachable, since the abscess followed a penetrating injury. It was not only in the capsular shadow but also in the regular shape that the pyographic appearances were those of a much older abscess (*Fig.* 348). We are at a loss to explain the speed of loculation and encapsulation in this case, though penetrating injury and youth are probably two factors which encourage early encapsulation.

In all these early cases the capsular shadow was visible by the time the abscess was 42 days old.

b. Late Appearances.—Once the capsule has taken up thorotrast the course of the abscess can be watched by examination of the capsular shadow. The capsular shadow is spherical, ovoid, or lobulated, and not always complete in all parts, especially when only small amounts of thorotrast have been injected and the head has not been moved about freely. The thorotrast is most profuse at the dependent part of the abscess (*Fig.* 352). After repeated aspiration, or as a result of natural resolution, the capsular shadow becomes thickened and crinkled as the abscess shrinks in size (*Fig.* 353).

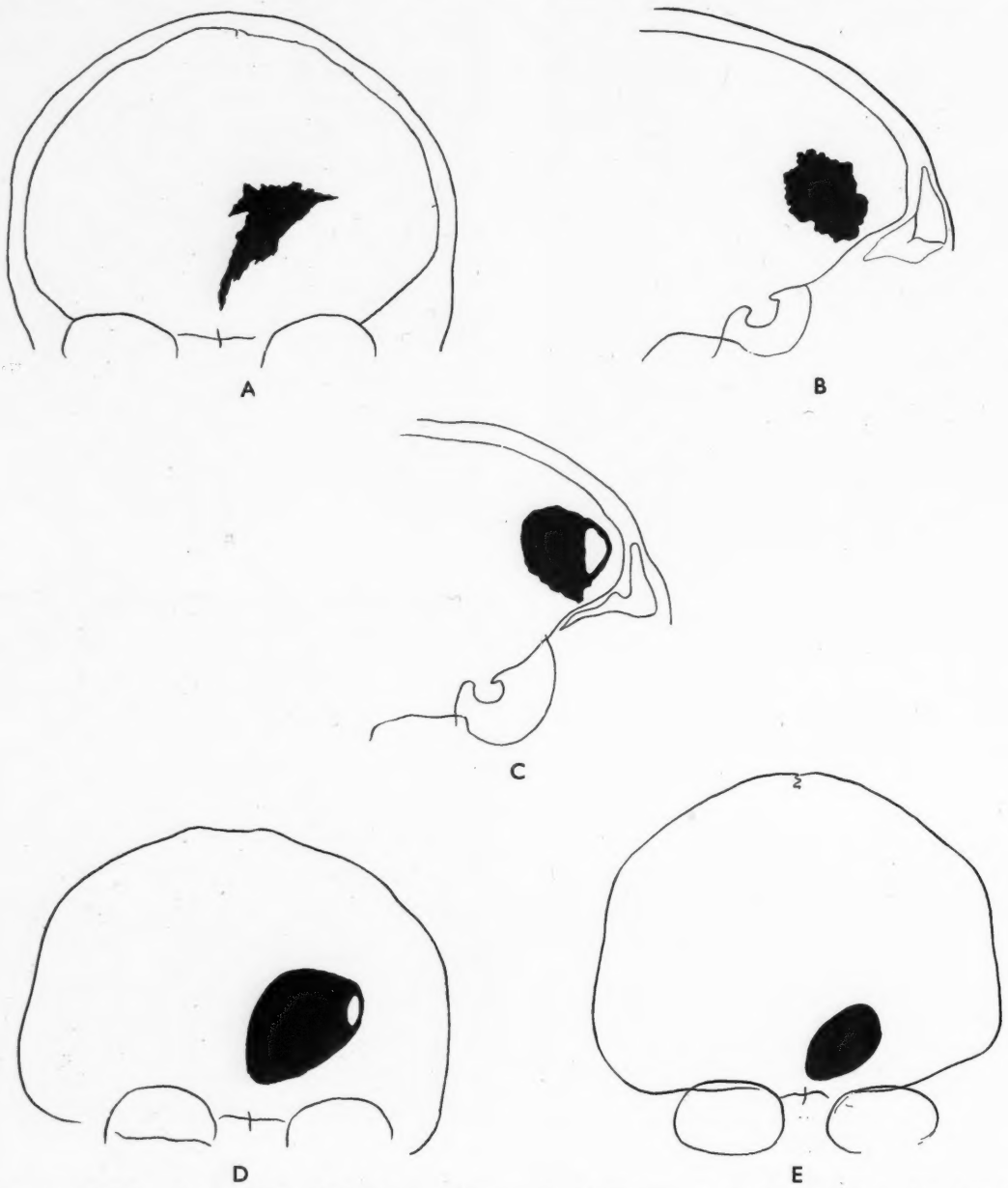


FIG. 351.—(GKT 1478.) *A left frontal-lobe abscess secondary to sinusitis (B. proteus). Serial line drawings which show changes in shape and size following repeated aspiration.*

A, B, Anteroposterior and lateral views taken six hours after the aspiration of pus and instillation of 2 c.c. of thorotrast. The cavity is irregular in shape and collapsed. The protrusion from the inferior surface suggests the probable site of origin, and subsequent operation showed this to be from the orbital extension of the left frontal sinus.

C, D, Ten days later the abscess is assuming a pyriform shape and the thorotrast has diffused as a cloud throughout the cavity. A small air bubble outlines the capsular shadow. Note the protrusion on the inferior surface of the shadow.

E, Eleven weeks after the first instillation of thorotrast, just before removal of the abscess. A radiograph of the excised abscess is shown in *Fig.* 347 B.

FIG. 352.—*A bilocular frontal abscess following a fracture of the anterior fossa.*
A, On Jan. 9, 1942, the ventriculogram shows no filling of the anterior horn.
B, Four days later. The bilocular abscess a few hours after the aspiration of pus and instillation of thorotrast; the thorotrast lies at the most dependent part of each loculus.
C, Four days later after another aspiration. The capsular shadow is taking up the thorotrast.
D, Five days later. There is a 'tail' on the ventricular side of the posterior loculus. After this aspiration the patient had a brief attack of meningitis.
E, On Jan. 28, apart from the 'tail', a thin wavy line can be seen in the situation of the temporal horn. It is believed to be thorotrast taken up by the choroid plexus. The waves of meningitis following aspiration are thus explained—doubtless the temporary shrinkage following aspirations opened up a small communication with the anterior horn of the lateral ventricle in the region of the 'tail', and allowed infection to reach the cerebrospinal fluid.
F, Just before removal of the abscess; the capsular shadow is now well defined and measures 2 mm. in thickness.

FIG. 353.—(R.I. 20559/43.) *A chronic parietal abscess which followed osteomyelitis of the overlying vault, approximately 11 weeks old.* The diseased bone has been removed. The crinkled capsular shadow measured 2·5 mm. in thickness.

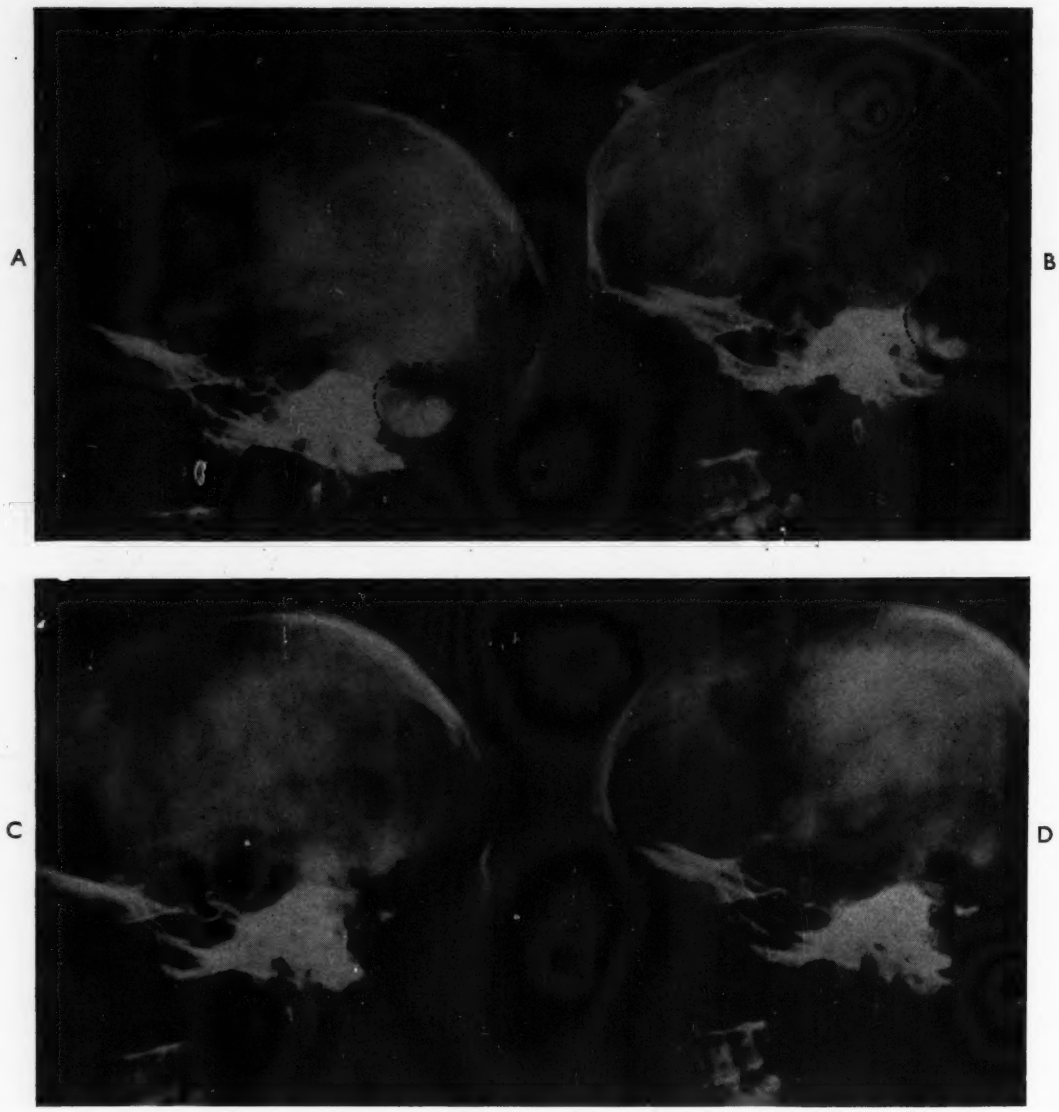


FIG. 354.—(R.I. 7826/40.) *An otogenic cerebellar abscess in a child.*

A, On April 20, 1940, two days after the first aspiration and instillation of thorotrast, the abscess measured 26 × 33 × 24 mm.

B, Five days later the child had deteriorated fairly rapidly, and her clinical state simulated meningitis. However, the pyogram showed that the abscess was larger (29 × 36 × 28 mm.) and this enlargement proved to be the cause of the deterioration.

C, D, After another aspiration the abscess progressively contracted to a tiny shadow which was closely applied to the posterior surface of the petrous bone. This was not removed. Seven years later the child was alive and well and the thorotrast-impregnated scar was still present.

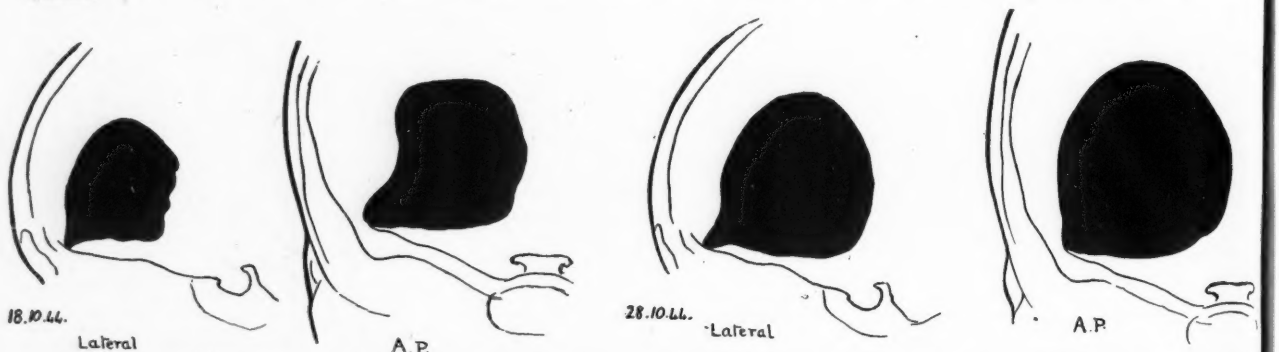


FIG. 355.—(R.I. 34250/44.) *A frontal abscess secondary to frontal sinusitis in a young woman. Line drawings which show the extent of enlargement which can be symptomless.* Between Oct. 18 and Oct. 28, 1944, irregularities of the capsular shadow were 'ironed out' as tension inside the abscess increased. Clinically there was no subjective or objective change in the patient's condition at this time. The site of origin and attachment to the floor of the anterior fossa is shown by the peaked prolongation of the capsular shadow on its antero-inferior surface.

The final stage, if the abscess is not excised, is a tiny opaque cicatrix (*Figs.* 354, 356, 358).

When an abscess is enlarging, its outline becomes smoother and more spherical (*Figs.* 355, 358), and we regard this tendency to become spherical as indicating increased tension in the abscess.

Tracks and Communications.—The attachment of the abscess to the coverings of the brain can usually be demonstrated in the form of an offshoot of the main capsular shadow (*Figs.* 350, 351, 352 C, 355, 360). This will be considered in detail later.

Sometimes there is a patent track and in some cases of abscess connected with the petrous bone, thorotrast injected into the abscess cavity has been observed in the mastoid cavity (*Fig.* 350). In one case thorotrast injected into a temporal abscess escaped from the ear, leaving only a trace in pyograms; this observation indicated that the profuse purulent discharge from the ear arose chiefly from the brain abscess and not from mastoid disease; as soon as the brain abscess had been excised the aural discharge ceased.

Another form of track is that in which the thorotrast leaks back along the track of the brain needle. This only occurred in 3 cases of this series and at the first injection. No harm resulted. Thorotrast leaked from an abscess into the lateral ventricle in 2 cases (*Figs.* 352, 362).

Contraction and Migration.—As an abscess shrinks in size it moves towards the site of its attachment, which may not have been obvious in the first pyogram (*Fig.* 356). This is almost invariable in

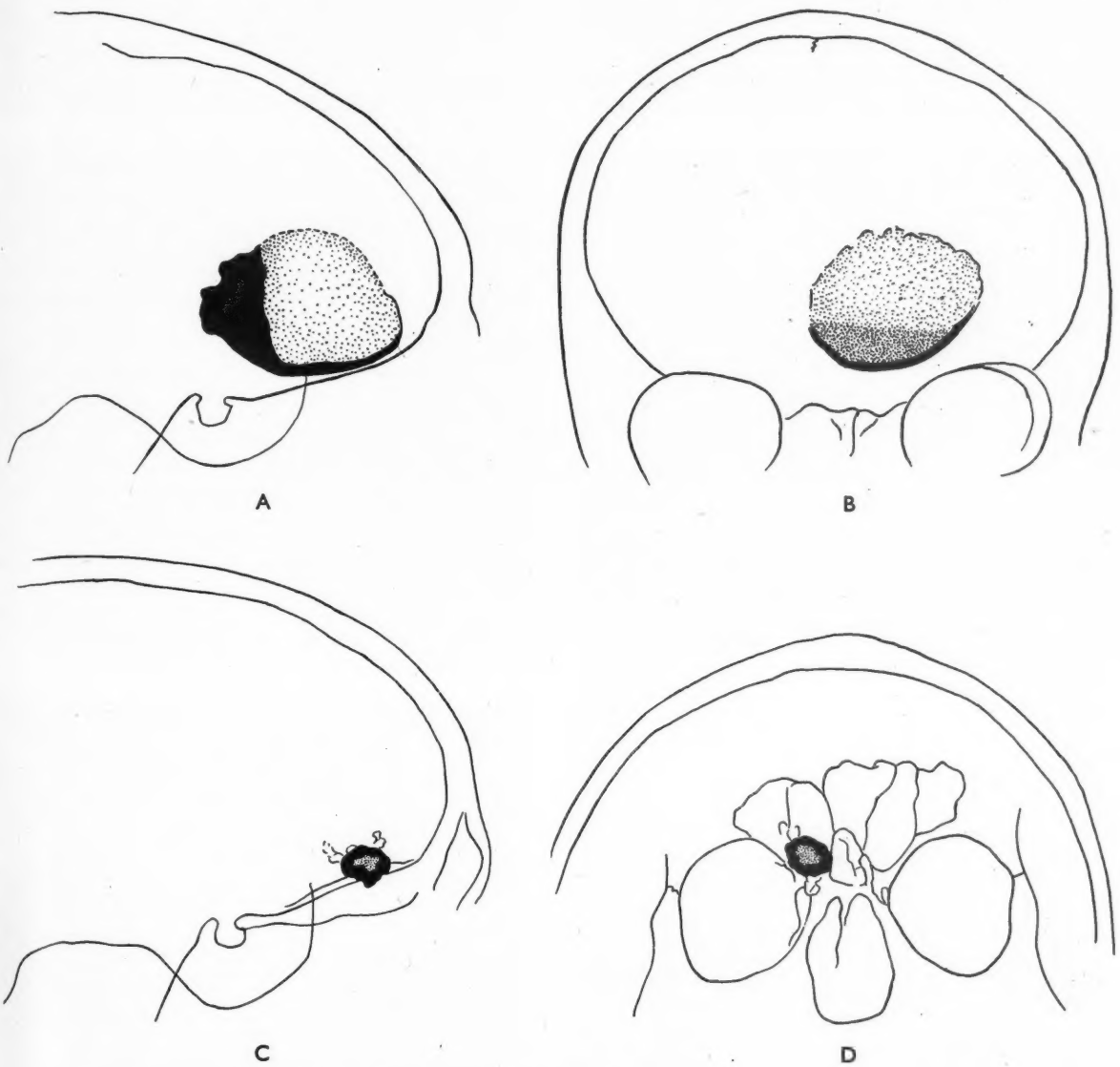
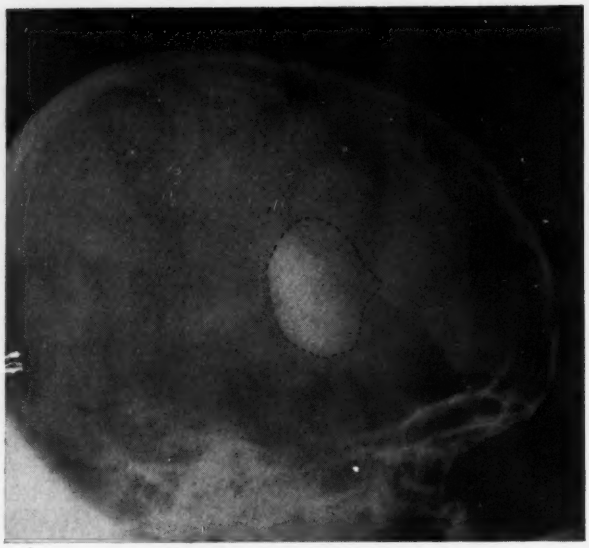


FIG. 356.—(G.K.T. 1468.) *A frontal abscess secondary to ethmoidal sinusitis.*

A, B, Line drawings of radiographs taken six hours after the aspiration of pus (*H. streptococcus*) and instillation of thorotrast and penicillin. The irregular shadow is typical of an early pyogram. Note also the 'false' capsular shadow due to thorotrast lining or coating the most dependent parts of the abscess.

C, D, Line drawings of the same abscess fifteen weeks later. The crenated thorotrast-impregnated cicatrix has migrated to the site of origin from the ethmoid air cells. In A and B there was no evidence that this was the site of origin. Radiating spicules of thorotrast in the pericapsular tissues probably indicate the spread of thorotrast-laden phagocytes beyond the capsular shadow proper. The latter is 3 mm. thick and the original abscess cavity is still visible.



A

B

FIG. 357.—(R.I. 43342/45.) *A bilocular frontal abscess following a small penetrating wound in the frontal region.* A, Radiograph of the abscess containing thorotrast. Previous pyograms showed that the shadow was becoming smaller. However, clinically there was little improvement and signs of raised intracranial pressure remained. On the anterior aspect of the capsule a peak or spout can just be made out. This is the site of attachment to an invisible anterior loculus. The wound lay well forward and was adherent to the anterior loculus. The excised specimen is seen in B.

abscesses due to direct spread of infection from the petrous bone (both temporal and cerebellar abscesses), from the paranasal sinuses, and from any focus of osteomyelitis in the vault of the skull. When an abscess due to direct spread from an extradural focus shrinks and does not retreat towards its site of origin the assumption is that there is an intervening loculus present which has not been tapped (*Fig.* 357).

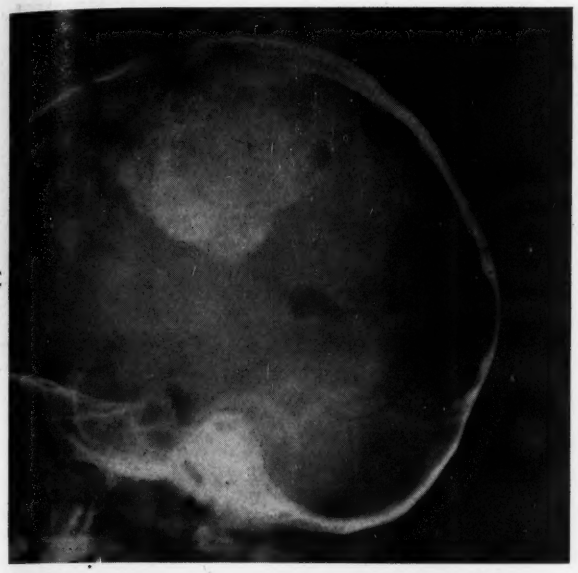
Loculation.—Loculation was present in just under half of the cases examined by pyography (23 of 56). It was significantly frequent in the traumatic cases. The loculi were recognized at the time in 12 cases; in 9 others they were at first overlooked, though they were actually visible or their presence could have been inferred; in the remaining 2 cases loculi were only found on examination of the excised abscess and could not reasonably have been diagnosed from the pyograms.

In temporal and cerebellar abscesses the loculi usually communicated freely with one another, and were thus easily demonstrated by pyography. In the frontal abscesses, on the other hand, the loculi were usually farther apart from one another and were in some cases not easily filled at the first injection of thorotrast, though their presence could be inferred from the later radiographic appearances. The importance of multiple X-ray projections to display the loculi, particularly in the early pyograms, cannot be overestimated.

We have considered the question whether loculi are caused by excessive needling of the brain abscess. The balance of evidence suggests that this is not a common cause of loculation. Often the loculi can be seen in the earliest pyograms. Moreover, once

A

B



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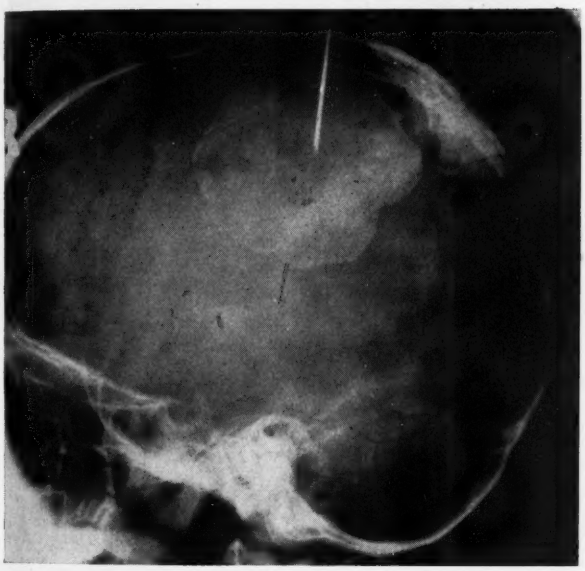

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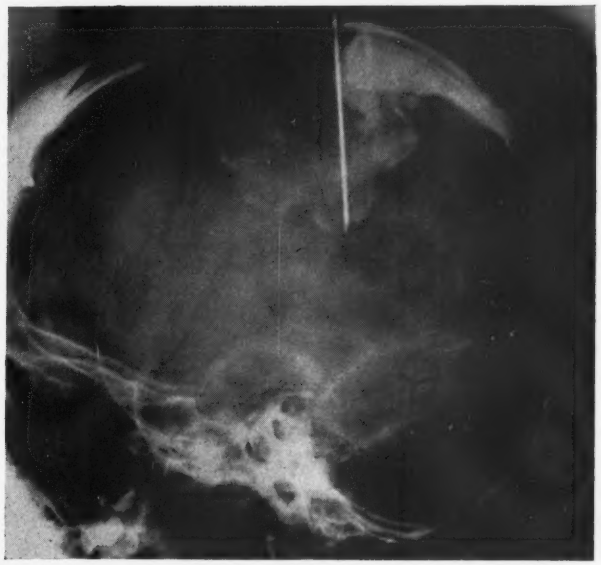

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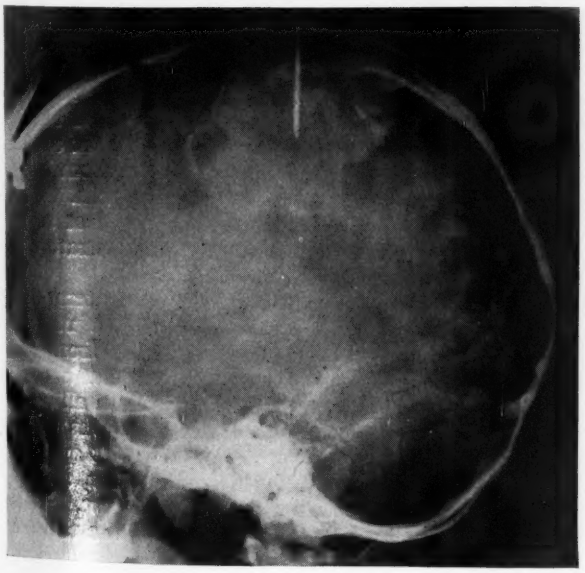

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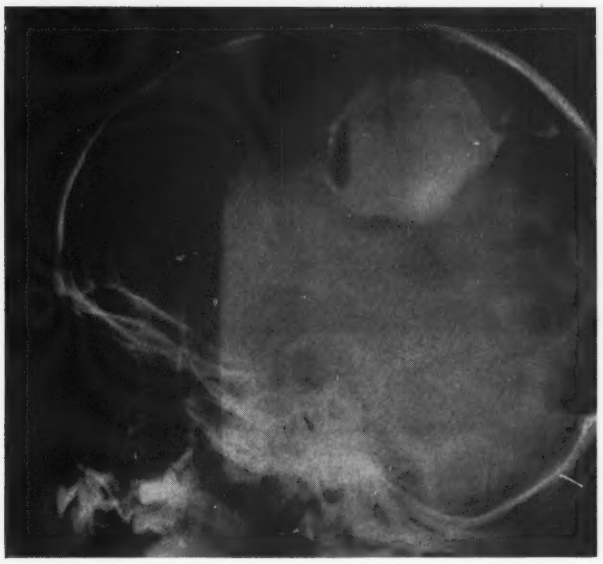

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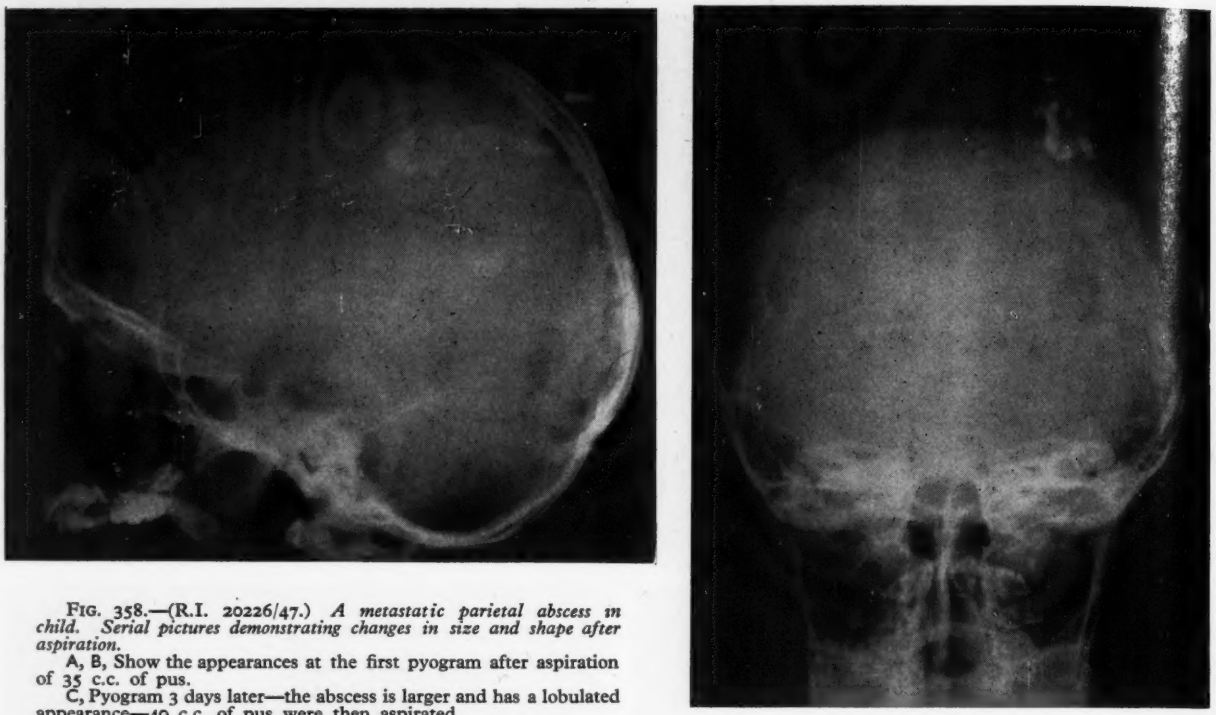


FIG. 358.—(R.I. 20226/47.) *A metastatic parietal abscess in child. Serial pictures demonstrating changes in size and shape after aspiration.*

A, B, Show the appearances at the first pyogram after aspiration of 35 c.c. of pus.

C, Pyogram 3 days later—the abscess is larger and has a lobulated appearance—40 c.c. of pus were then aspirated.

D, Routine pyogram one week later—although there were no symptoms or signs of deterioration, the abscess is larger. Note also the three burr holes—aspirations were made through the central one after the first pyogram had indicated the unsuitability of the other two.

E, Pyogram made the day after D (before any pus was aspirated) with a Greenfield lumbar-puncture needle in situ. The abscess has filled out even more in the intervening 24 hours, as shown by smoothing out of the lobulated form.

F, 35 c.c. of pus were then aspirated. The shrinkage and increase of lobulation are seen and the point of the needle is sealed by the capsule, which has shrunk down on to it.

G, The needle was withdrawn a little and a further 15 c.c. of pus aspirated.

H, One week later the abscess has enlarged again and has a smoother contour. Appearances are now those of a chronic abscess. The posterior projection towards the first burr hole suggests leakage along the track of the first aspirating needle; 30 c.c. of pus were then aspirated.

I, J, Four weeks later the thorotrast-impregnated cicatrix has now contracted down to a small scar. The child was seen again two months later and the appearances were similar. He was extremely well and had no neurological signs. The site of the lesion in the Rolandic region was a contra-indication to removal.

thorotrast is injected into the abscess any leakage of pus to form a second loculus may be expected to show in the pyograms and this we have not observed.

Changes in Size and Shape of Abscess Shadow after Aspiration (*Figs.* 358, 359).—After the initial aspiration, when one thinks the abscess has been emptied, it is surprising to find how large the pyogram shadow still is.

In most cases the abscess enlarges again within 24–48 hours, and after a second aspiration the abscess once more tends to enlarge within a few days.

In this series before the stage of chronic quiescent encapsulation was reached the average number of aspirations required was 2 in 34 unilocular abscesses (extremes 1 and 5) and 3 in 23 multilocular abscess (extremes 1 and 8). Some of the unilocular abscesses failed to diminish in size despite repeated aspiration and the finding that after local penicillin treatment cultures of the pus had become sterile. The tendency of an abscess to enlarge repeatedly could be explained by bleeding into the abscess cavity in some cases (*Fig.* 359) but not in all. Sometimes, presumably, the attachments of the abscess in the depths of brain were so firm as to prevent collapse of the abscess cavity. These questions are far from settled and we merely wish in this paper to draw attention to the accuracy with which the progress of the abscess can be followed in repeated pyograms.

ABSCESSES AT SPECIAL SITES

Temporal Abscess (13 cases).—It is outside the scope of this communication to speculate on the exact mode of direct spread of infection from an extradural focus to the formation of an intracerebral abscess in those non-traumatic cases where the meninges are intact. Probably in many cases spread takes place along a vein which passes through the meninges. Such a mode of spread would explain well the operative finding of a fibrous cord to the petrous bone or wall of a paranasal sinus. On the other hand, a broad-based attachment of the abscess to the bone suggests direct spread from bone to dura to brain without passage along a vein. The pyograms in 'direct-spread' abscesses will at some stage, usually in the early pictures, demonstrate one or other of these types of attachment.

Such evidence was found in 10 of the 13 temporal lobe abscesses (*Fig.* 360). Three had a narrow communication, 5 a narrow prolongation from the inferior aspect of the capsule, and 2 had broad-based attachments to the petrous bone. In all cases the site of origin appears on the radiographs to be the same. In the anteroposterior views it appears to lie just laterally to the eminentia arcuata, and in the lateral projections anterior to the crest. This area on the petrous bone corresponds to the tegmen tympani.

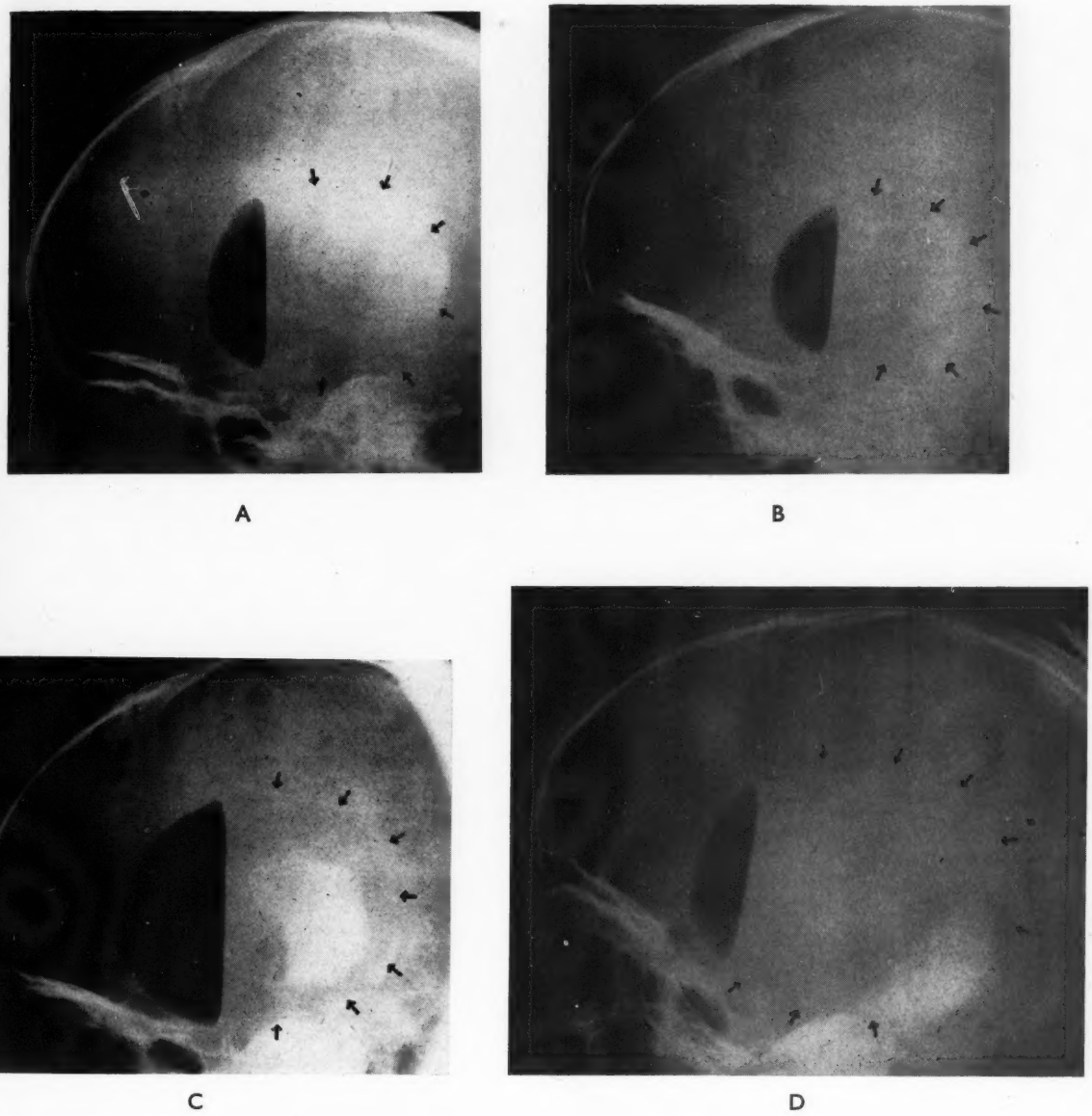


FIG. 359.—(R.I. 72646/47.) *Further pictures of the abscess shown in Fig.* 349. *Bleeding into an abscess after aspirations.*
A, The first pyogram—an unusually large amount of air is present; 160 c.c. of pus were aspirated 12 hours before this picture was taken.
B, The second pyogram taken next day, 3 hours after removal of 95 c.c. of blood-stained pus. The shadow is only slightly smaller.
C, Ten days later. Picture taken before aspiration of 120 c.c. of bloody pus.
D, Two days later. The abscess is larger (even when allowance is made for slight rotation of the X-ray film). The abscess was removed *in toto* one week later and the patient recovered.

More than one loculus was present in one-third of the temporal abscesses, and, except for one case, they were easily demonstrated on the pyograms. These loculi, like those in the cerebellum, tend to lie closely together and resemble a bunch of grapes. Intercommunication is usually free. In this connexion they differ from those in the frontal region.

Cerebellar Abscesses (10 cases).—Nine of these were due to direct spread from the ear, and one was a metastatic tuberculous infection (*Fig.* 361). Of the otogenic group, 3 had broad-based attachments to the posterior surface of the petrous bone on the pyograms and 1 had a fistulous track into the mastoid (*Fig.* 350). In 2, treated by repeated aspiration only, an attachment to the petrous bone was not seen in the early pyograms, but the otogenic origin was confirmed by the contraction and migration of the cicatrix towards the petrous bone (*Fig.* 354).

Parietal and Occipital Abscesses (10 cases).—Eight were metastatic from thorax or abdomen, and two followed osteomyelitis of the vault of the skull. The metastatic lesions were all in the common site for hæmatogenous abscesses, i.e., in the distribution of the middle cerebral artery. *Fig.* 358 illustrates an abscess of this group which recovered.

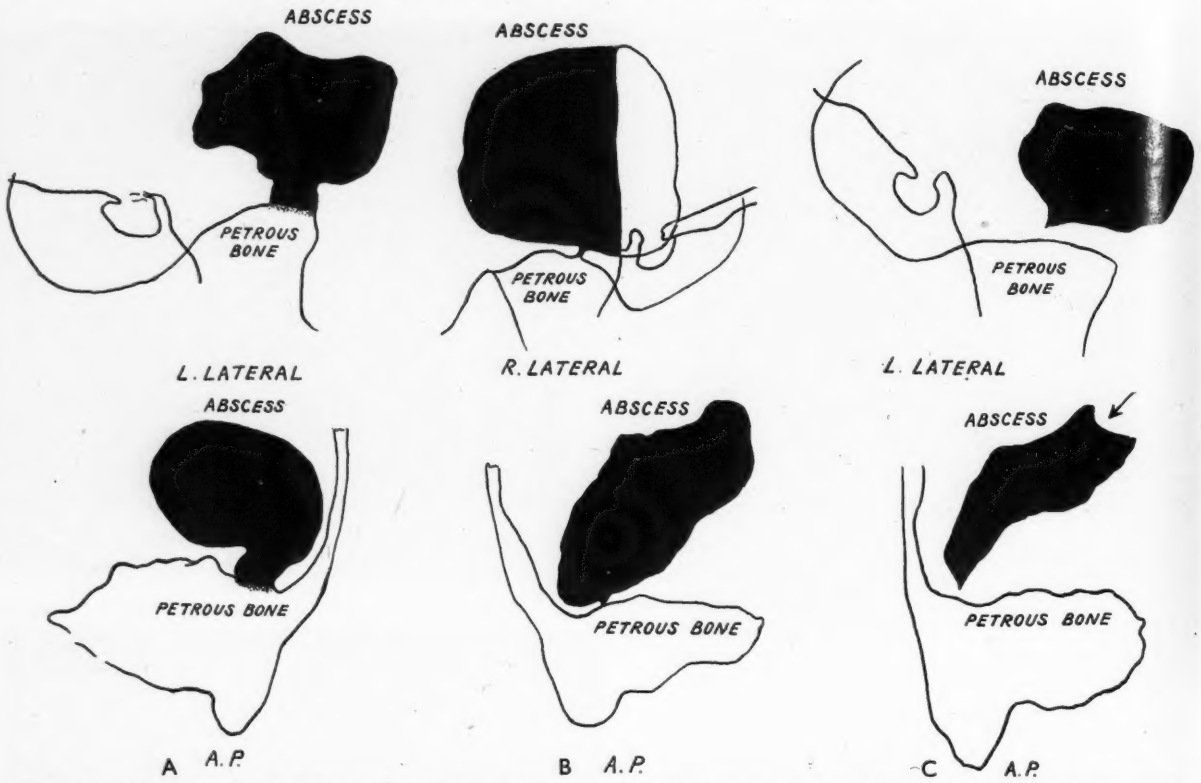
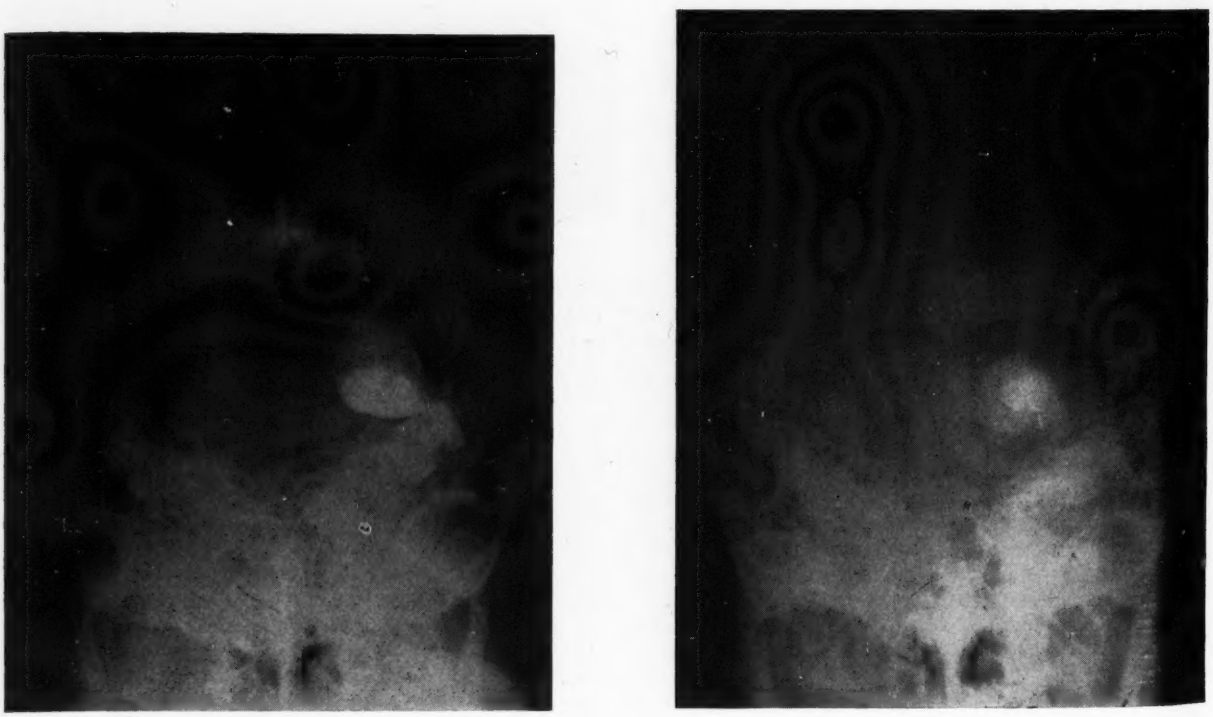


FIG. 360.—(A, R.I. 68971/47 ; B, R.I. 20226/41 ; C, R.I. 61139/46.) *Line drawings of three typical temporal lobe abscesses of otogenic origin, to show attachment to the petrous bone.* Anteroposterior and lateral projections are depicted in each case. Significant points are : (1) The constant position of the abscess just above the superior surface of the petrous bone. (2) As it enlarges upwards the abscess extends medially. In (C) the anteroposterior projection shows a notch on the medial surface (arrow) which probably outlines the temporal horn of the ventricle. (3) The evidence of origin from the bone either by a broad based attachment (A), a small track (B), or a tenting of the inferior part of the capsule (C).



A B

FIG. 361.—(R.I. 10188.) *A tuberculous abscess in the left lobe of the cerebellum.* There is little change in size in the two pictures taken at an interval of four and a half weeks. At operation, when the abscess was removed no communication existed with either the petrous bone or the dura. Supporting evidence that this was a metastatic lesion carried by the blood-stream was the finding of pulmonary tuberculosis and the patient's death from this disease eighteen months later.

Early rupture of such abscesses into the ventricle is well known and *Fig.* 362 illustrates this complication, a thorotrast ventriculogram being produced.

FIG. 362.—(R.I. 55045/46.) *A metastatic parietal abscess secondary to pulmonary suppuration.* The abscess has ruptured into the lateral ventricle and produced a thorotrast ventriculogram (*arrows*). The main abscess cavity is seen just posterior to the burr hole and is well outlined by the thorotrast. A bubble of air remains in the anterior horn and the outline of the lateral ventricle is seen as a thin cloud. The patient died four days later.

Frontal Abscesses (19 cases).—Twelve followed a paranasal sinus infection and 7 followed penetrating non-missile injuries. Six cases in each group had a second loculus. The striking features about the group as a whole are as follows :—

1. The almost invariable indication on the early pyograms of the site of the origin of the abscess, as shown by a tenting or prolongation of a part of the capsule towards the infected sinus or wound (*Figs.* 348, 351, 352, 355).

2. The high incidence of loculation. We have subdivided the pyographic appearances of frontal abscesses with loculi into three groups which are depicted in a diagram (*Fig.* 363).

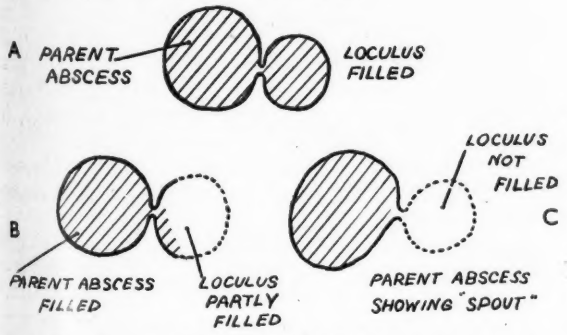


FIG. 363.—*A schematic drawing of the three types of pyogram observed in the frontal abscesses in which there was more than one loculus.*

In A both loculi are well outlined and the communication between them can be seen (*Figs.* 348, 352). In B one loculus is well filled and the other only partly so. The communication may or may not be seen (*Fig.* 364). The loculus which is only partly filled may lie closely applied to the other, and may indent it. In C only one loculus is filled. The communication between the two is seen as a peak or spout.

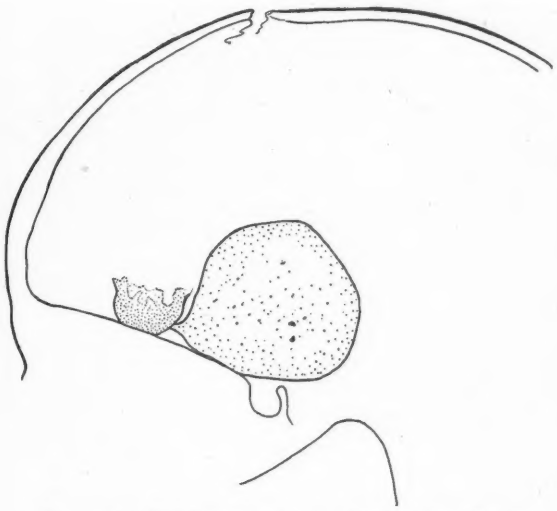


FIG. 364.—(R.I. 35175/44.) *A bilocular frontal abscess secondary to infection of the orbital extension of the frontal sinus.* The line drawing shows the partly outlined anterior loculus—and the communication between it and the well-filled posterior loculus. Group (*B*).

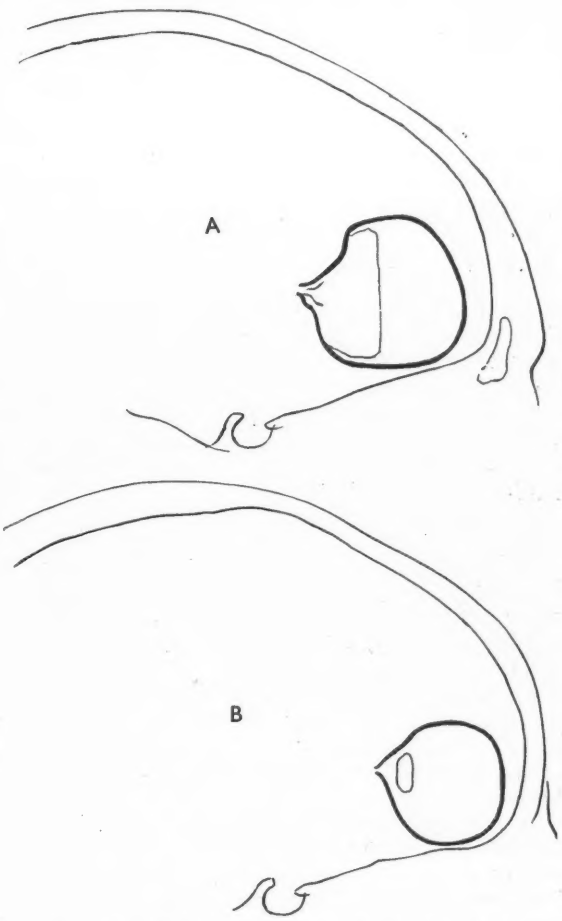


FIG. 365.—(R.I. 61253/46.) *A bilocular frontal abscess secondary to suppuration in the frontal sinus.* The peak or spout on the posterior part of the capsular shadow is seen in both A and B. In B, taken fourteen days after A, the visible loculus was smaller, but the patient's clinical condition was deteriorating and pressure signs persisted. At operation the visible abscess and a large loculus behind it were successfully removed. The spout indicates the partially filled communication between the two.

Group A (6 cases): The diagnosis of loculation was obvious in all because both loculi were filled. *Fig.* 352 shows the serial appearances of such a case. The occurrence of waves of meningitis following aspiration suggested that the abscess was leaking into the ventricle and the pyograms confirmed this.

Group B (3 cases): The thorotrast was limited to one loculus and to the adjacent part only of the wall of the other loculus. In two cases of this group the significance of the pyographic appearances was misinterpreted and the presence of two abscesses not realized until operation (*Fig.* 364).

Group C (3 cases): The presence of another abscess was missed in all three cases because the second abscess was not outlined at all by thorotrast. The key to diagnosis in this type of case is progressive shrinkage of the visible abscess, with either clinical deterioration or failure to improve. In each of these three cases a sprout or nipple on the capsule of the first abscess which was constant in position on successive pyograms pointed to the second abscess (*Figs.* 357, 365).

Subdural Abscess.—There were 4 cases where an intracerebral abscess was associated with a subdural abscess in this series. When the subdural abscess lies between the falx and tentorium on the one side and the medial and inferior surfaces of the cerebral hemisphere on the other, which is one of the common sites for subdural abscess, the pyographic appearances are diagnostic (*Fig.* 366).

Subdural abscess in this situation is usually only found by needling deeply through the brain substance, and the only certain way of distinguishing it from a deep-seated brain abscess, or from pyocephalus, is in the characteristic shape of the pyographic shadow. As our cases showed, subdural abscess may be associated with a cerebral abscess; but recent work in this department has demonstrated that subdural abscess secondary to purulent pachymeningitis, usually with spreading osteomyelitis of the skull, may exist without an underlying cerebral abscess (Schiller, Russell, and Cairns, 1948).

VALUE OF PYOGRAPHY

1. Indication of the Correct Site for the Burr Hole for Aspiration.—The track of the aspirating needle in the brain should always be short and if possible away from regions like the motor area. Only pyograms can give the precise localization needed; *Fig.* 358 illustrates the point well—two burr holes were made before the first pyogram showed that the abscess was lying between them; a third burr hole was then sited directly over the abscess.

2. Indication of the Size and Shape of the Abscess and hence the Indication for Retapping.—After the acute phase is over, enlargement of an abscess may be quite symptomless. Thus, in one case (*Fig.* 358) aspiration was undertaken immediately with satisfactory results; but in another (*Fig.* 355) the increase in size was not immediately brought to the notice of the surgeon and 30 hours later the patient suddenly went into a coma and died, despite immediate removal of the abscess. Reliance on clinical evidence of enlargement as an indication for retapping is dangerous and a waste of precious time. Impressions of enlargement are fallacious, and three-dimensional measurements of an abscess on comparable radiographs should be made. Then the pyograms will not mislead.

In a cerebellar abscess of this series the patient's deterioration suggested clinically an attack of meningitis, but comparable pyograms (*Fig.* 354) showed that the abscess was larger; immediate aspiration of the abscess relieved the symptoms.

3. Indication of the Site of Origin.—In abscesses caused by direct spread, pyograms indicate the site of origin by showing the attachment or prolongation of the capsular shadow towards the primary focus of infection. Pyography thus provides information which cannot always be obtained from clinical examination and straight radiographs, and this may be useful in treatment. Thus, in a parietal abscess the presence of a prolongation towards the skull suggests a local focus; its absence suggests a distant focus, e.g., the lungs, and the need for further investigations such as bronchoscopy. In this latter type of case, when the brain abscess has been successfully dealt with the primary bronchiectasis is sometimes treated surgically (Pennybacker and Holmes Sellors, 1948).

4. Indication of the Progress of Capsule Formation and hence the Age of the Abscess.—Abscesses which have a definite fibrous capsule have been shown to take up thorotrast within about 4 days. In this series the average thickness of the capsule of 23 abscesses at the time of operative removal was 2·7 mm. and the presumed average age in days was 76. Probably these abscesses could have been removed earlier if systematic measurements of the capsular shadow had been made. In all cases at least three pyograms should be done and the capsule shadow shown to be getting thicker before reliance is placed on measurements, since in the early days 'coating' of the lining of the abscess, in contra-distinction to the active taking up of the thorotrast by the histiocytes of the abscess wall, can give a misleading appearance.

5. Indication of the Presence of more than One Loculus.—The presence of a second loculas which has not been filled with thorotrast is a danger of the method. The surgeon may easily be misled and seek for other causes of the patient's failure to improve. Thus, in this series, of the 23 cases with loculi, 9 were at first overlooked. We believe that all but one of these could have been surmised after a careful scrutiny of all the pyograms (*Fig.* 363), in conjunction with clinical findings. There is a considerable element of chance in the filling of loculi, which largely depends on whether or not intercommunication exists.

In temporal and cerebellar abscesses multiple loculi usually communicate, whereas in one-quarter of our frontal abscesses they did not communicate.*

* Indentation as a diagnostic sign of an unfilled loculus was not observed in this series. The irregular outline of an abscess is a constant for that particular abscess and is modified only as tension varies in its cavity (*Fig.* 358). Persistent deformity on its own should be regarded with caution as evidence of a second loculus unless accompanied by the other criteria already mentioned.

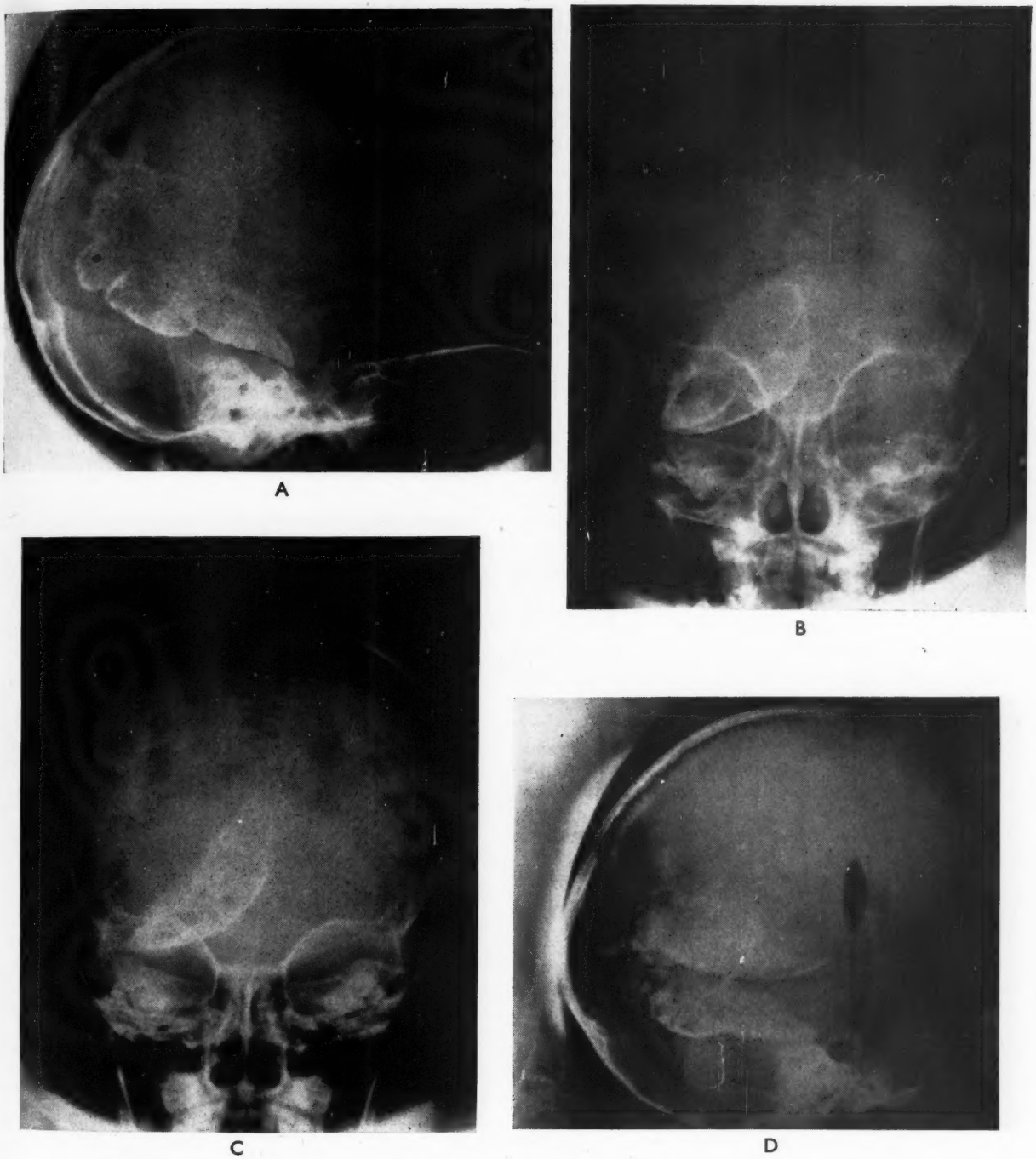


FIG. 366.—(R.I. 25501/44.) *Subdural and intracerebral abscesses following mastoiditis in a child aged* 3 (*H. influenzæ*). A, B, Pyograms, two weeks after instillation of thorotrast, which show a large subdural collection between the tentorium and the under-surface of the occipital lobe. The feathery appearance in the lateral projection is characteristic of late pyograms of subdural abscess. C, Three weeks later, after another five aspirations. The elliptical shadow is narrower and becoming indented on its supero-lateral side. In spite of the further spread of the sutures the child was no better, and in the following week a large intracerebral collection was found (D). A bubble of air outlines its anterior extent.

Post-operative radiographs are advisable to make sure all loculi have been removed. In one case in this series a small thorotrast-filled loculus was left behind—radiographs over the next year showed that it contracted to a small opaque cicatrix.

6. **Indication of the Presence of a Subdural Abscess.**—A deeply-seated subdural abscess can only be diagnosed by pyography.

DISADVANTAGE OF THOROTRAST IN CEREBRAL ABSCESS

The possibility of the radio-activity of thorotrast must be considered. Its dangers are certainly negligible if the abscess is excised, but where a thorotrast-impregnated cicatrix is left some reaction may occur. No reactions have been recorded in

this series; however, since our earliest thorotrast pyograms were only made 8 years ago it would be unwise to be dogmatic without further proof.

We have inquired into the frequency of fits following the use of thorotrast pyograms and there does not appear to be a significantly higher incidence in cases thus treated.

SUMMARY AND CONCLUSIONS

1. The pyographic appearances of 56 cases of cerebral abscess are reviewed, with particular reference to the serial appearances, changes in shape, size, tracks, communications, and loculation.

2. The value of pyography is discussed.

3. From a systematic study of pyograms more can be learned about brain abscesses than has been possible in the past. The management of these cases is greatly assisted by the visual control which is possible by this method.

We wish to express our thanks to Professor Sir Hugh Cairns for his great help in preparing this paper. We should also like to thank Mr. J. Pennybacker, who operated on many of the cases, for valuable help and criticism. We are indebted to Miss A. Arnott for all the line drawings, and to Mr. Tugwell, of the Photographic Department, for the reproduction of radiographs.

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A STUDY OF POST-OPERATIVE PULMONARY ATELECTASIS

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THE so-called 'post-operative chest' is still a common cause of stormy convalescence, morbidity, and occasional mortality following operation, usually on the upper abdomen. The majority of post-operative chest complications are due to some form of pulmonary collapse, either segmental or lobular, the difference being of degree rather than kind. Causes of collapse are now generally accepted as bronchial occlusion with mucus plugs and inadequate ventilation of the lung bases. Accessory factors are said to be the pre-operative use of the atropine group of drugs which dry up bronchial secretion, morphine derivatives which depress the cough reflex, and tight abdominal binders which limit expansion of the lung bases. In addition there is the post-operative wound tenderness which makes the patient disinclined to take deep breaths.

The highest incidence of collapse occurs after upper abdominal operations. In a previous paper (Goodwin, 1946) the author has reviewed the figures given by American workers. King (1933) found an incidence of 14 per cent in a group comprising all laparotomies, while in operations on the stomach, duodenum, and gall-bladder it was 35–46 per cent. In the first group pulmonary complications occurred after general anæsthesia in 12 per cent of cases, after spinal anæsthesia in 16 per cent, and after local anæsthesia in 18 per cent. Henry (1943) has stated that collapse occurs in 10 per cent of all abdominal operations and in 30 per cent of all operations in the epigastric region. Hara (1942) gives 2–4 per cent as the incidence in all operations, and is of the opinion that collapse occurs in up to 70 per cent of all post-operative chest complications.

Considerable emphasis has in the past been placed on the effect of drugs used for premedication, the type of anæsthetic, and the post-operative administration of morphine. In a classical paper, Brock (1936) has shown the importance of pre-operative respiratory tract infection, coryza, sinusitis, pharyngitis, and acute bronchitis, in the causation of collapse. The presence of chronic lung disease, particularly of the bronchi, such as chronic bronchitis and bronchiectasis, has also rightly been stressed as an important factor. The significance of emphysema unaccompanied by much bronchitis has not yet been assessed. Emphysema presumably would predispose to collapse by virtue of the diminished respiratory excursion.

In the past there has been a tendency to divide post-operative collapse into a number of types, the classification usually being based upon the extent of the collapse. Schotz (1943) has described three types, segmental, lobular, and 'creeping' atelectasis.

The evidence obtained from the clinical material studied in this series strongly suggests that cases of post-operative atelectasis differ only in degree, and that any sharp division into groups is artificial and tends to over-complicate the problem. The severity of the clinical picture is, as might be expected, directly proportional to the degree of collapse. For this reason it has been found convenient for descriptive purposes to introduce a simple classification into this paper, but it should be clearly recognized that there is no sharp dividing line between the three groups described, and that experience has shown that many cases occur which cannot be fitted into

any rigid scheme of classification. Patients fall into three groups :—

Group I.—

a. Massive Collapse of the Lung.—No cases occurred in this series and clinical experience suggests that this degree of post-operative collapse is very rare.

b. Segmental Collapse.—Atelectasis of one or more lobes, or of segments of lobes. There are definite radiological changes.

Group II.—Lobular Collapse with Radiological Changes.

Group III.—Lobular Collapse without Radiological Changes.

Group I (*b*) occurs when a large mucus plug is arrested in a segmental bronchus, or when a lobular collapse has become confluent. Groups II and III occur when either a large plug breaks into small particles which block distal bronchioles or when aggregations of terminal bronchioles collapse owing to retained secretion and inadequate alveolar aeration.

Group I gives rise to definite physical and radiological signs, which are too well known to need description here. Patients with Group II and III collapse frequently exhibit few physical signs, and radiological signs are equivocal and difficult to interpret. I hope to show that lobular collapse can occur with no radiological signs, and should be differentiated on clinical grounds alone, from bronchitis, bronchiolitis, and primary bronchopneumonia.

Plan of Investigation.—Sixty-three cases showing post-operative chest complications were studied. Of these 63 cases, 60 had some degree of pulmonary collapse, while of the remaining three, 1 had congestive cardiac failure, 1 a right phrenic nerve palsy following operation for cervical rib, and 1 a small pulmonary embolus. All patients had been examined before operation and any abnormal physical signs in the chest or upper respiratory tract were noted. Where possible a pre-operative radiograph of the chest had been taken. After operation portable radiographs were taken after 12 hours and then at 2–3-day intervals.

Results.—In this series of 60 cases, 34 (57 per cent) showed segmental collapse (Group I), 8 (13 per cent) showed lobular collapse with X-ray changes (Group II), and 18 (30 per cent) were diagnosed as lobular collapse without detectable radiological changes (Group III).

Groups II and III have an identical clinical picture.

The Diagnosis of Lobular Collapse with or without Radiological Changes (Groups II and III).—The history in these cases usually follows a definite pattern. Six to twenty-four hours after operation the patient develops a painful cough with scanty mucopurulent sputum, occasionally blood-stained. The temperature, respiration-rate, and pulse-rate are elevated, but the pyrexia is usually out of proportion to the pulse and respiration rates. There may be pain of pleuritic type over the basal areas of one or both lungs.

Physical Signs in the Chest.—These may be very slight and vary from impaired percussion note at one or both bases with impaired air entry and basal râles, to basal râles alone, but this last finding is constant. Radiological changes, when present (Group II), consist of slight crowding of the vascular markings in the cardiophrenic angle in the postero-anterior film and in the posterior basic segment in the lateral film. A frequent finding is depression of the interlobar fissure on the right side. Diaphragmatic elevation is an almost uniform finding on the right side and is probably due more to the pneumoperitoneum than to lung collapse. Occasionally there may be small woolly opacities at the bases, but these usually indicate a confluent lobular collapse, indistinguishable from segmental collapse.

It may be argued that there is no proof that Group II cases have any collapse, and that such patients are suffering from acute primary bronchitis, bronchiolitis, or bronchopneumonia.

The fact, however, that cases of Groups II and III are identical clinically suggests that both are of similar aetiology. The focal quality of the lesion in Group III cases excludes acute bronchitis, diffuse bronchiolitis, and bronchopneumonia, the physical signs in these conditions being disseminated throughout the lungs.

It must be admitted that symptoms and signs in Groups II and III are identical with those to be found in cases of bilateral basal bronchiolitis and bronchopneumonia. Pyrexia, which might be considered to favour the diagnosis of a purely infective lesion, is in fact common to both collapse after infection has occurred and primary bronchopneumonia. But having regard to the frequency of pulmonary collapse after abdominal operation, and bearing in mind the factors favouring collapse rather than a primary infection, and the exact clinical similarity between Groups II and III, there is strong inferential evidence in favour of cases of Group III being due to collapse.

The following cases are illustrative :—

Case 1.—D. B., a healthy man of 25, was subjected to appendicectomy under general anæsthesia on March 15, 1947. Before the operation he had a dry cough and coryza. On the next day his cough became worse and he began to expectorate nummular sputum. His temperature rose to 100° F. and he became slightly dyspnœic. Physical examination of the chest revealed crepitations at the left base. Radiography of the chest on March 17 (*Figs.* 367, 368) showed collapse of the posterior basic segment of the left lower lobe. He was treated with sulphamezathine 1½ g. six-hourly, an expectorant mixture three times daily, and inhalations of 5 per cent CO_2 for five minutes every hour. An abdominal binder, applied after the operation, was removed. On March 18 he appeared better, but the temperature was still 100° F. and there was impairment of percussion note, air entry, and vocal resonance at the left base. On March 21 his temperature was normal, there was no sputum, and there were no signs at the left base. On March 24 he developed a temperature of 100° F. and the cough recurred. Examination revealed crepitations and some impairment of percussion note at the left base. X-ray examination showed total collapse of the left lower lobe (*Figs.* 369, 370).

Penicillin inhalations and postural drainage were instituted, and by March 31 there were no symptoms or physical signs. X-ray examination showed the collapsed lobe to have expanded completely (*Fig.* 371).

Comment.—The case illustrates the following points :—

1. Radiological evidence of segmental collapse may be present in conjunction with physical signs identical with those found in cases of Groups II and III collapse.

FIG. 367.—*Case* 1. Portable postero-anterior radiograph, March 17. Very slight crowding of left lower ribs. No definite evidence of collapse.

FIG. 368.—*Case* 1. Portable left lateral radiograph, March 17. Collapse of posterior basic segment of the left lower lobe.

2. The occurrence of pyrexia at the onset of collapse on both occasions suggests that these collapsed areas rapidly became infected.

3. The insidious progressive nature of post-operative collapse.

4. The value of postural drainage.

FIG. 369.—*Case* 1. Portable postero-anterior radiograph, March 24. Collapse of left lower lobe.

FIG. 370.—*Case* 1. Portable left lateral radiograph, March 24. Triangular shadow indicating complete collapse of left lower lobe.

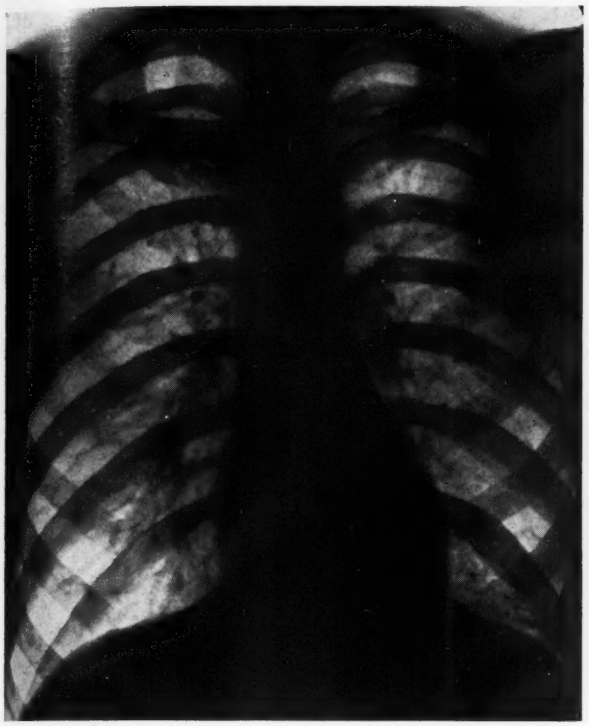

FIG. 371.—*Case* 1. Postero-anterior radiograph, March 31. Complete re-expansion except for a tiny area of linear collapse above the left diaphragm.

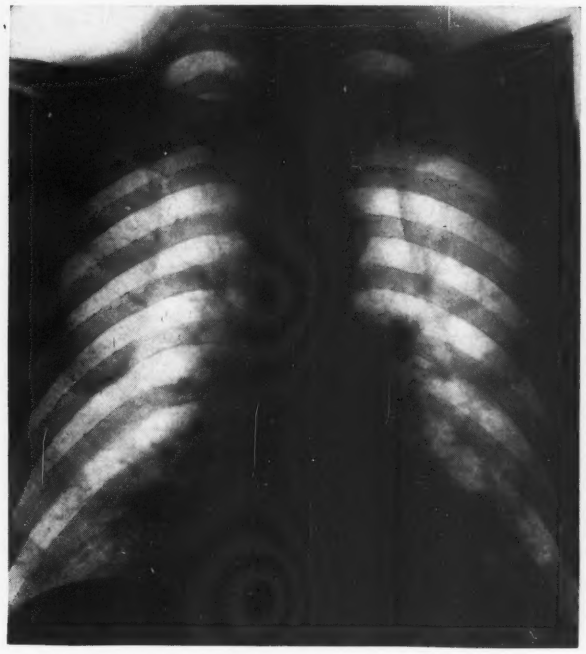

FIG. 372.—*Case* 2. Portable postero-anterior radiograph. Patchy segmental collapse at both bases.

Case 2.—A man, aged 46, with emphysema was subjected to partial gastrectomy under general anæsthesia. Prior to operation he had a cough with sputum but a pre-operative chest radiograph was normal. Twenty-four hours after operation the cough became worse and sputum was plentiful, the temperature rose to 100° F., and he became dyspnœic. On examination he was found to be cyanosed, with crepitations at the bases of both lungs. X-ray examination showed patchy segmental collapse at both bases (*Fig.* 372). With full treatment his temperature returned to normal in two days and marked subjective improvement was noted. Three days later there was still radiological evidence of collapse, but considerable re-expansion had occurred (*Figs.* 373, 374). Three days later (thirteen days from onset) there was complete re-expansion of both lower lobes and he

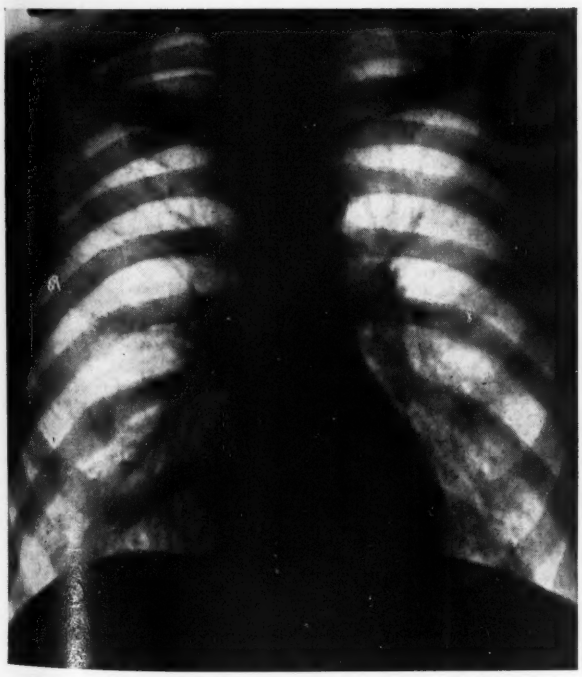

FIG. 373.—*Case* 2. Portable postero-anterior radiograph, three days after *Fig.* 372, showing considerable re-expansion.

FIG. 374.—*Case* 2. Portable right lateral radiograph at the same time as *Fig.* 373. Residual collapse at the right base.

was asymptomatic (*Fig.* 375.) The physical signs were confined throughout to basal crepitations. There was no clinical evidence of segmental collapse and the case might well have been diagnosed incorrectly on clinical grounds as primary bronchiolitis or bronchopneumonia.

Comment.—This case, with extensive segmental collapse, presented the same clinical signs and symptoms as cases of Group III collapse without radiological evidence of atelectasis.

FIG. 375.—*Case* 2. Postero-anterior radiograph, three days after *Figs.* 373 and 374. Complete re-expansion with slight residual basal congestion.

The fact that no X-ray changes are present cannot be taken as excluding lobular collapse. Radiological signs of minimal collapse are notoriously equivocal, even with 6-ft. films, but in portable films on ill patients the recognition of collapse is even more difficult. Often a small area of collapse which is not detectable on the postero-anterior film can be detected in the lateral film.

All cases of collapse in this series developed some pyrexia, which strongly suggests that areas of post-operative atelectasis rapidly became infected.

Stringer (1947) has shown that radiological signs of atelectasis could be seen in films taken four hours after operation, and in some cases that these signs had disappeared when a further film was taken 24 hours after operation. In the four-hour film increased vascular markings at the bases were noted, but were not taken to indicate collapse unless other signs were present in addition. Assessing the incidence of post-operative collapse on radiological signs alone, he found that of 50 patients 26 had post-operative chest complications and that of these 26 cases 13 showed signs of atelectasis.

In my series of 60 cases, 18 were diagnosed as lobular collapse without X-ray changes (Group III), making an incidence of 42 cases with radiological collapse, or 70 per cent of the total chest complications. This is rather higher than Stringer's finding of radiological collapse occurring in 50 per cent of cases with post-operative chest complications. I suggest that a substantial proportion of his cases without radiological collapse were in reality cases of Group III collapse.

The importance of diagnosing and suitably treating cases of Group III collapse, lies in the prevention of further collapse. *Case* 1 illustrates how a small area of collapse may insidiously increase unless correct treatment is instituted.

Terms such as 'post-operative chest', 'bronchitis', and 'pneumonia' should be discarded entirely unless there is unequivocal clinical evidence of such conditions. There is no doubt that post-operative bronchitis does occasionally occur, particularly in patients who have pre-existing chronic bronchitis and who suffer exacerbations. Clinical "post-operative pneumonia" is in my view nearly always the result either of segmental collapse, or, in a minority of cases, of a pulmonary infarct with superadded infection.

Table I.—OPERATION AND ANÆSTHETICS IN CASES OF COLLAPSE

CASES WITH ATELECTASIS	OPERATION	ANÆSTHETIC
	Cases	Cases
Laparotomy	42	
Hernia	10	
Craniotomy	1	
Prostatectomy	2	General 58
Transthoracic vagotomy	3	Local 2
Thyroidectomy	1	
Hæmorrhoidectomy	1	
TOTAL	60	60

All patients were given the routine pre-operative medication with morphine and atropine or omnopon and scopolamine. Morphine was not withheld post-operatively.

Pre-operative Infection of the Upper Respiratory Tract.—The influence of infection before operation was not considerable; of the 60 cases, 29 (48 per cent) had previous infection. Of these 29 infected cases, 18 (62 per cent) suffered Group I segmental collapse, 6 (21 per cent) suffered Group II collapse, and 5 (17 per cent) suffered Group III collapse. Of the 31 cases without infection 16 (52 per cent) suffered segmental collapse, 2 Group II collapse, and 13 Group III collapse. There was thus a slightly higher incidence of cases of segmental collapse in the infected group.

Type of Lesion found pre-operatively in Infected Nases.—3 cases had some pre-existing pulmonary collapse, 9 cases had chronic bronchitis and emphysema, and 17 cases had coryza, cough, and sinusitis.

Site of the Collapse.—In all instances the collapse was basal. It occurred in the right lung in 28 (47 per cent) cases, in the left lung in 13 (22 per cent), and in both lungs in 19 (32 per cent).

Sex Incidence.—

44 (73 per cent) of cases were male.

16 (27 per cent) were female.

Type of Onset.—Of the 60 cases, the onset was sudden in 11 (18 per cent) and insidious in 49 (82 per cent). Of the cases with sudden onset, 8 (72 per cent) were segmental, 1 (10 per cent) was of Group II, and 2 (18 per cent) were of Group III. Of the cases with insidious onset 26 (53 per cent) were segmental, 6 (12 per cent) of Group II, and 17 (35 per cent) of Group III.

Treatment.—

Prophylactic.—Prophylactic treatment aims at teaching the patient adequate breathing exercises before operation and adequate drainage and disinfection of lung areas in cases where infection is present, and will not be discussed further in this paper.

Treatment of Established Condition.—The essential factors in treatment are the promotion of coughing to expel mucous plugs, the ensuring of adequate respiratory movements to aerate the bases of the lungs, and chemotherapy to eliminate infection. In cases where a tenacious mucous plug has obstructed a large bronchus causing lobar collapse various manœuvres have been designed to discharge the plug (cf. Sante's manœuvre, quoted by Foster Carter and Marshall, 1943). The most effective method is postural drainage with chest percussion, once or twice daily. In addition, chemotherapy is essential to control the infection.

Post-operative morphine has in the past been withheld in some cases owing to its effect on the respiratory centre. However, I have not seen the use of post-operative morphine in normal dosage lead to any aggravation of existing collapse. The use of post-operative atropine is theoretically undesirable but probably not dangerous in normal dosage. De Takats (1942) recommends the intravenous injection of atropine to relax bronchial spasm, and papaverine to induce vasodilation.

Tight binders constricting the lower chest and making any sort of respiration difficult had been applied in 7 cases in this series. In all cases binders were abandoned and the wound protected by an elastoplast corset which did not encroach upon the lower ribs.

Inhalations of 5 per cent CO_2 to promote hyperpnœa is approved by some (J. Marshall, 1944; Goodwin, 1946), and disapproved by others (G. Marshall and Foster Carter, 1943). The theoretical objection is that the hyperpnœa may draw mucous plugs farther into the bronchial tree. This may be so, but is unlikely to have any harmful effects if postural drainage is correctly carried out.

Bronchoscopy: Brock has stated that a large proportion of cases recover without bronchoscopy, and this is undoubtedly true. Hara (1942), Henry (1943), and Schotz (1943) all agree that bronchoscopy is of value and should be performed early—within 24 hours of collapse. Henry advises bronchoscopy under nembutal anæsthesia and cocainization of the larynx. It is of interest that Grandstaff (1945) has recently claimed dramatic results in post-operative atelectasis by applying 5–10 per cent cocaine to the pharynx and larynx as if in preparation for bronchoscopy. He suggests that cocainization of the larynx acts by producing a reflex relaxation of the bronchial musculature, since the same results were not obtained by merely irritating the pharynx with a swab and producing a cough.

It was previously my view that bronchoscopy should be carried out in cases of segmental collapse if no sign of re-expansion occurred within 24–48 hours under postural treatment. In the light of recent experience I am now sure that it is not only justifiable, but expedient, to wait for at least two weeks before considering bronchoscopy, unless of course, there is any suggestion of an intrabronchial foreign body. Correct postural and ancillary treatment will result in re-expansion in most cases.

The following cases illustrate the failure of bronchoscopy :—

Case 3.—A woman, aged 52, developed a collapse of the right lower lobe 24 hours after thyroidectomy under general anæsthesia (*Fig.* 376). She was first seen a week later and given the full treatment régime, which resulted

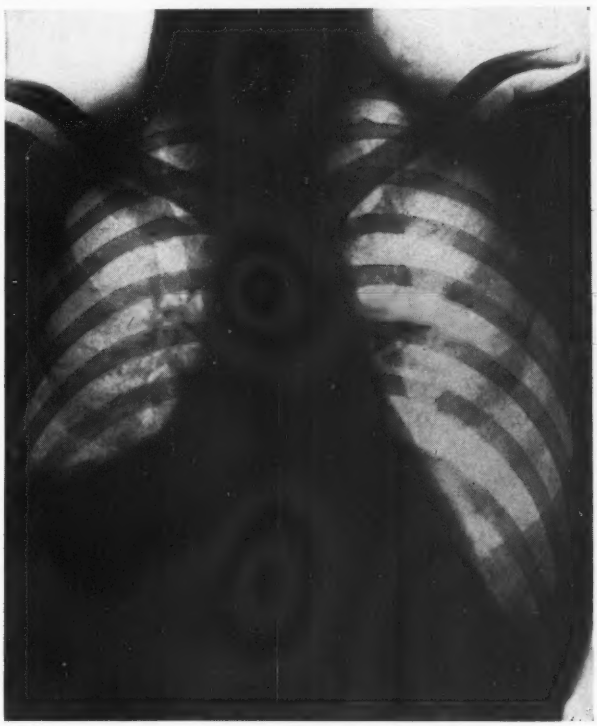

FIG. 376.—*Case* 3. Portable postero-anterior radiograph. Collapse of right lower lobe.

in a marked subjective improvement and a drop in temperature from 101° to 99° F. after 2 days. As there were no signs of re-expansion, bronchoscopy was performed (18 days after onset and 2 days after start of treatment). Some pus was removed from the right main bronchus. Two days after bronchoscopy the temperature was still 100° F. and there was no X-ray or clinical evidence of re-expansion. Full treatment was continued, and the lobe began slowly to re-expand. Four weeks after the onset she was asymptomatic and X-ray examination showed a small area of collapse only (*Fig.* 377). Later (6 weeks from the onset) there were no physical signs and radiography showed complete re-expansion (*Fig.* 378). She was completely asymptomatic.

Comment.—This case illustrates the failure of bronchoscopy to achieve re-expansion even though pus was removed from the bronchus concerned. It seems probable that disseminated bronchiolar blockage was added to the obstruction of the right lower lobe bronchus,

so that only painstaking bronchial drainage and chemotherapy achieved re-expansion. The period of collapse was longer than that found in most other cases in the series, although after the first few days she felt very well and was almost asymptomatic.

Case 4.—A man of 59, with chronic bronchitis and emphysema, developed a total collapse of the right lower lobe following prostatectomy. Postural drainage and chemotherapy having had no effect, he was bronchoscoped two weeks after the occurrence of collapse.

FIG. 377.—*Case* 3. Portable postero-anterior radiograph, four weeks after onset. Considerable re-expansion has occurred.

Nothing abnormal was seen, and the lower lobe still refused to expand. Bronchograms later showed no evidence of bronchiectasis or bronchial neoplasm.

Treatment of the Established Collapse in this Series: Full treatment consisted of penicillin by intramuscular injection, 120,000 units six-hourly and also by inhalation three times daily (200,000 units in 10 c.c. *N* saline, using a simple inhaler with a bakelite face mask). Breathing exercises were performed once daily and the patient instructed to take ten deep breaths every hour. A simple saline expectorant mixture was used. Postural drainage was not usually commenced until at least 24 hours after the operation, as it was found that many patients were unable to tolerate this earlier.

Of the 60 cases treated, 45 received the full treatment, while 15 were treated by other methods such as chemotherapy alone, expectorant mixtures, or postural drainage alone.

Full treatment was given to 29 of the 34 cases of segmental collapse, 7 of the 8 cases of Group II collapse, and 9 of the 18 cases of Group III collapse.

Duration of Collapse in Fully Treated Cases.—It was impossible to assess accurately the effect of treatment on the duration of collapse owing to a large number of varying factors such as preceding infection, other post-operative factors, age of the patient, degree of co-operation, etc. Of the 29 cases with segmental collapse which had full treatment, the average duration of collapse in days has been assessed in 18 patients. The other 11 cases are not included by reason of various complicating factors which need not be enumerated here.

The average duration of segmental collapse in this group was found to be 16 days.

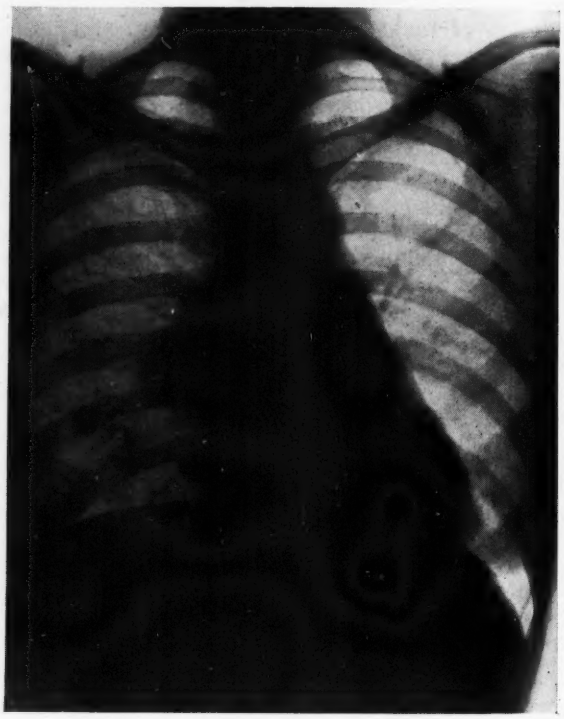

FIG. 378.—*Case* 3. Postero-anterior radiograph, six weeks after onset. Complete re-expansion.

The average duration of collapse in cases of Group II was 12 days, and in Group III 7 days.

The average duration of collapse in 3 cases of segmental collapse with other types of treatment was 31 days.

The average duration of collapse in 9 Group III cases who received other treatment was 10 days.

Although the control groups are too small to be significant, these results suggest that a combination of chemotherapy, postural drainage, and breathing exercises may be superior to other forms of treatment.

Subjective Results of Treatment.—A marked subjective and symptomatic improvement resulted in all cases after 24–36 hours of full treatment, even in cases when re-expansion was not complete for 7–14 days or longer. Fall in temperature usually paralleled the re-expansion of the lung. This subjective improvement was much more marked in these cases than in cases receiving other treatment.

Not unnaturally, most chronic bronchitics stated that they had less chest symptoms after treatment than before the operation.

Follow-up.—Where possible cases have been followed up at three-monthly intervals in the Out-patient Department. Records are as yet incomplete.

CONCLUSIONS

From this series of cases it may be concluded that some form of pulmonary collapse is the most frequent post-operative chest complication, is always basal, occurs most frequently in the right lung, and after upper abdominal operation. Pre-operative upper respiratory tract infection is found in nearly 50 per cent of all cases of collapse. Collapse may be segmental, lobular with X-ray changes, and lobular without X-ray changes, but the difference is one of degree only and there is no clinical mandate for a clear-cut division into different types.

Lobular collapse of slight extent may occur without any radiological signs, and patients thus affected present a definite clinical picture identical with that seen in cases of lobular collapse accompanied by X-ray changes. Cases of the former type should not be diagnosed as bronchopneumonia or bronchiolitis, which they resemble clinically, but should be treated as cases of post-operative collapse of the lung. Infection rapidly occurs in collapsed areas.

Post-operative bronchitis presents an entirely different picture and is extremely rare except as an exacerbation of previous chronic asthmatic bronchitis.

Many patients with minor degrees of collapse will recover without any specific therapy. A proportion, however, will develop segmental collapse. The prophylaxis of segmental collapse should be early recognition and adequate treatment of lobular collapse. Correct treatment tends to shorten the duration of collapse and relieve the patients' urgent symptoms.

A highly satisfactory method of treatment consists of chemotherapy with penicillin, postural drainage, and breathing exercises. This therapy will cause complete re-expansion in uncomplicated cases of segmental collapse within 16 days, and of lobular collapse within 7–12 days.

Bronchoscopy is not indicated until at least two weeks' adequate medical treatment has been given without effect, or unless an intrabronchial foreign body or neoplasm is suspected.

Delay in starting treatment considerably prolongs the duration of collapse.

SUMMARY

Sixty-three cases of post-operative chest complications were studied by clinical and radiological methods. Sixty cases were diagnosed as collapse of the lung. Three groups of collapse were recognized—segmental collapse (Group I); lobular collapse with radiological signs (Group II); and lobular collapse without radiological signs (Group III). Forty-two cases had radiological in addition to clinical signs of collapse. The other 18 presented a clinical picture identical with patients who showed radiological evidence of lobular collapse.

Of the 42 cases with radiological signs, the collapse was segmental in 34 and lobular in 8.

Inferential evidence is brought forward to support the view that Group II cases had lobular collapse rather than localized bronchopneumonia or bronchiolitis.

Of the 60 cases of collapse 42 had been submitted to upper abdominal section, and 58 had received general anæsthetics. Twenty-nine cases had previous upper respiratory tract infection. The incidence of segmental collapse was higher in the infected than in the uninfected group. The collapse in all cases was basal and involved the right lung in 47 per cent, both lungs in 32 per cent, and the left lung in 22 per cent of cases. The onset of the collapse was insidious in 49 (82 per cent) and sudden in 11 (18 per cent) cases. Of the cases with sudden onset (8) 72 per cent had segmental collapse. Treatment is discussed and a régime is described consisting of penicillin by intramuscular injection and inhalation, postural drainage, breathing exercises, and inhalation of 5 per cent CO_2. With this treatment the average duration of segmental collapse was 16 days, of Group II collapse 10 days, and of Group III collapse 7 days. The marked subjective improvement which occurred is noted, and the importance of so treating cases of lobular collapse in order to prevent the development of segmental collapse is stressed. It is pointed out that although many cases of lobular collapse will recover satisfactorily with other forms of treatment, the duration of collapse is likely to be shortened if the recommended treatment is used. Four cases are described to illustrate the physical and radiological signs and response to treatment. Bronchoscopy is considered to be contra-indicated unless treatment has been carried out for at least two weeks without result, or there is a suspicion of an intrabronchial neoplasm or foreign body.

No advantage is to be gained by adopting a sharply defined classification of post-operative collapse, since on clinical grounds cases do not fit into a rigid plan, but merge imperceptibly from one group into another.

Thanks are due to Professor R. St. L. Brockman, Mr. A. W. Fawcett, Mr. W. J. Lytle, and Mr. Clifford Jones for kindly providing facilities for studying their cases; and to the Surgical First Assistants, House Surgeons, and Nursing Staff at the Royal Infirmary for their help and co-operation. I also wish to thank Professor E. J. Wayne for much help and encouragement during this investigation and in the preparation of this paper, and Drs. Wilkie and Steiner for their assistance with radiological problems.

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SOME OBSERVATIONS ON THE FUNCTIONAL ANATOMY OF INGUINAL HERNIA AND ITS BEARING ON THE OPERATIVE TREATMENT

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ANATOMY is at the present time in a phase of activity and expansion, and surgery is both an agent and a beneficiary of this activity. A principal feature is the change from a static to a functional concept of anatomy. The change of approach in the case of inguinal hernia has, however, been slow. The operation devised by Bassini (1890) was such an

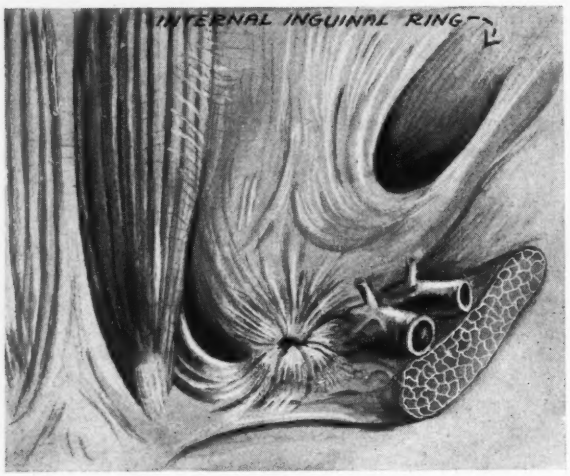

FIG. 379.—The right femoral and inguinal regions viewed from the inner aspect. (After a drawing of Hamilton Russell's to illustrate his article on femoral hernia, in which incidentally the sling-like character of the transversalis fascia at the internal ring was shown.)

advance on all previous operations for inguinal hernia, and the principles underlying it seemed so sound (namely, to re-constitute the posterior wall of the inguinal canal by suturing behind the cord the conjoint muscle and tendon to the upturned edge of the inguinal ligament, and thus to re-constitute the obliquity of the inguinal canal) that it long remained a standard surgical procedure, immune even from serious criticism. But the theoretical weakness of Bassini's operation was that it treated the conjoint muscle and tendon as though they were inert rather than actively functioning tissues. McGavin (1909), Handley (1918), and Gallie and Le Mesurier (1921) recognized this, and devised the operations known after their names which aimed at strengthening the posterior wall of the inguinal canal without distorting and maiming the conjoint muscle and tendon. Handley, and later Gallie and Le Mesurier, pointed out that such forcible distortion of the muscle was usually ineffective in that the stitches either cut out or the muscle split.

More recently, the trends have been towards regarding the functional anatomy of indirect and of direct inguinal hernia as related but distinct; and secondly, towards according the transversalis fascia an increased importance in both types of hernia as constituting the first, although admittedly thin, line of defence. In England, Harold Edwards (1943) was a pioneer in advocating re-suture of the enlarged internal ring as the essential procedure after removal of the sac in indirect inguinal hernia. Later, Lytle (1945) published important detailed anatomical studies on the internal ring. He showed that the transversalis fascia at the internal ring constitutes a sling attached laterally and that on muscular contraction this sling is pulled upwards and laterally so that the opening tends to lie under and be protected by the medial curved edge of the internal oblique as it takes origin from the inguinal ligament. The sling-like character at the internal ring had been previously recognized (e.g., Hamilton Russell, 1923—*see Fig.* 379), but its functional significance was not appreciated until the work of Lytle.

Influenced by the work of Lytle, my own approach has been to study the functional anatomy of inguinal hernia at operation by stimulating the associated muscles by a faradic current. The results are best considered under two headings—first, the functional anatomy of indirect inguinal hernia; and secondly, the functional anatomy of direct inguinal hernia.

THE FUNCTIONAL ANATOMY OF INDIRECT INGUINAL HERNIA

If after identification and removal of the sac the margins of the internal ring are defined, and the conjoint internal oblique and transversalis muscles induced to contract by faradic stimulation, the

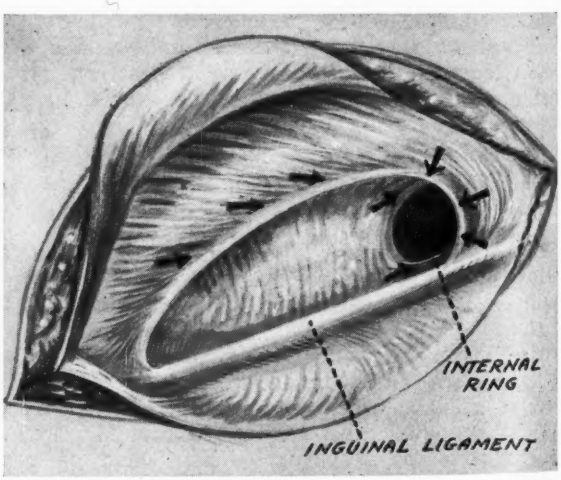

FIG. 380.—Diagrammatic representation of the left inguinal canal of a woman, to show the main directions of movement on muscle stimulation.

following functional mechanisms can be demonstrated:—

1. The pillars of the transversalis fascial sling constituting the medial margin of the internal ring are pulled laterally and upwards as described by Lytle. (*Fig.* 380.)

2. The arched fibres of the internal oblique constituting the lateral margin of the internal ring move medially. (*Fig.* 380.) And just as Lytle has demonstrated in the case of the transversalis fascial sling, this lateral mechanism, too, is best demonstrated if the muscle is put under tension, as by putting a finger or a small retractor at the internal ring and pulling laterally.

Sometimes the medial mechanism is the more strikingly developed, sometimes the lateral. Together, these two oppositely directed pulls constitute a double sling mechanism on superimposed planes, thus forming a mechanism comparable to that of a camera shutter. The protective valve to the internal ring is delicate and neat, but definite.

There are two other mechanisms which may play a minor part in protecting the internal ring. In the first place, the pull of the attachment of the internal oblique to the inguinal ligament may slightly elevate the latter and so protect the internal ring from below. This mechanism cannot always be demonstrated, but I have had one case in which the inguinal ligament at this point of origin of the internal oblique was measured to ascend 3 mm. Secondly, the contraction of the cremasteric muscle bunches the cord like a plug towards the internal ring, which action counteracts also the tendency for a pouch of peritoneum to prolapse into the cord. This mechanism is usually destroyed in operations for indirect inguinal hernia during dissection of the sac.

THE FUNCTIONAL ANATOMY OF DIRECT INGUINAL HERNIA

The posterior wall of the inguinal canal in the area where a direct inguinal hernia occurs is formed by the transversalis fascia (Lytle recognizes a double layer—the transversalis fascia proper and more superficially what he has termed the transversalis muscle fascia). If the conjoint internal oblique and transversalis muscles exposed at operation for hernia are stimulated electrically, the following functional mechanisms can be demonstrated :—

1. The transversalis fascia becomes tautened through the pull on its attachment to the deep surface of the transversalis muscle.

2. By the contraction of the combined internal oblique and transversalis muscles immediately above the transversalis fascia, the upper limits of what may be termed the direct inguinal hernia area are supported. The direction of movement of the conjoint muscle and tendon is laterally, i.e., towards the muscular part, so that the medial tendinous part is tautened (*Fig.* 380). There is a slight and just appreciable descent of the edge of the conjoint muscle and tendon due to the contraction of the muscle fibres circling round the lateral border of the internal ring already described. But nothing is seen or felt of an order approaching the shutter-like mechanism described by Keith (1923), who postulated that the " lower edge becomes pressed against and flush with Poupart's ligament, thus closing the inguinal gap ". The conjoint muscle and tendon are thus best regarded not as an arch but as a hook, contractile at its lateral part, hanging round the lateral aspect of the internal ring. On contraction, there is a general movement of the whole structure laterally towards the muscular part, as well as the embracing and protective action on the internal ring of the muscular hook itself which has been described above.

3. The inguinal ligament becomes tautened by the pull of the internal oblique attachment to it, and also by the contraction of the external oblique, so that the lower edge of the direct inguinal hernial area is supported. In addition, in cases in which the attachment of the internal oblique to the inguinal ligament causes a pulling up of the inguinal ligament, there may be a slight and barely appreciable elevation of the inguinal ligament more medially.

The main mechanism, therefore, protecting the direct inguinal area during muscular contraction is the tautened transversalis fascia, although the area gets added support at its superior and inferior borders with an associated slight diminution in width. This slight diminution in width is a secondary and minor effect of the protective mechanism at the internal ring already described, and due to the contraction of the muscular hook of the internal oblique lateral to the internal ring. But the total effect is to strengthen the shoulders of the gap rather than to fill the gap which is filled only by the transversalis fascia. The external oblique gives further support on a more superficial plane, and probably is an important protective agency for the direct inguinal hernial area, in contrast to its action in indirect inguinal hernia in which the external oblique seems to possess no protective function but merely controls the direction of descent of the sac.

THE APPLICATIONS OF FUNCTIONAL ANATOMY OF INGUINAL HERNIA TO ITS SURGICAL TREATMENT

INDIRECT INGUINAL HERNIA

If the functional anatomy of the internal ring is of importance, then its reconstitution is an essential step of the operation for hernia. In addition, any procedure which destroys or distorts the functional anatomy of the internal ring is theoretically wrong. On these premises, therefore, Lytle's procedure of resuture of the transversalis fascia pillars of the stretched and dilated internal ring should be a routine step after removal of the sac in the operation for indirect inguinal hernia ; otherwise, the protective mechanism of the ring remains impaired. The question arises whether anything further should be done. There is not as yet sufficient information about the late results of Lytle's operation to answer this question. But if experience should show that in some cases at any rate strengthening of the reconstituted internal ring is necessary, and this seems a probable conclusion, the further question arises of how best to achieve this object. Bassini's operation with or without the addition of a tension-relaxing incision in the rectus sheath is, on the principles given, unsound, as, apart from anything else, it distorts and interferes with the action of the internal oblique at the internal ring. Handley's silk darn and Gallie's fascia lata darn are both functionally sound and are admirably suited for cases in which the whole posterior wall of the inguinal canal is weak as well as the internal ring. But as a routine operation for simple indirect inguinal hernia in

which the weakness is limited to the internal ring both seem unnecessarily complicated. Bloodgood's operation (1919), in which a flap of the posterior lamella of the rectus sheath is turned back and sutured to the inguinal ligament, seems sound as regards the inguinal canal but may leave a weak spot at the linea semilunaris.* Brandon's operation (1945), in which the internal oblique muscle is cut at the internal ring is unsound in that it destroys the whole protective mechanism at the internal ring. Under these circumstances, I have lately been using to strengthen the reconstituted ring in cases of simple indirect inguinal hernia a strip of the posterior lamella of the rectus sheath still attached laterally by its muscular fibres which I bring through the muscle of the internal oblique and then attach through the upturned edge of the inguinal ligament. (*Fig.* 381, A–C.) This strip lies immediately superficial to the medial edge of the internal ring. It tautens with each contraction of the muscle, and seems to provide good support to the ring on an immediately superficial plane. The procedure has, however, been carried out in too few cases and too recently for anything to be said about its results. Apart from this, I have been exploring the possibilities of a greater preservation of the normal protective function of the cremaster, which, as already stated, is usually largely destroyed during the dissection of the indirect hernial sac. The muscle fibres of the cremaster seem to be disposed chiefly on the superficial aspect of the cord, and if the sac is approached from the deep aspect, it may be dissected free without gross interference with the function of the cremaster as demonstrated by its response to faradic stimulus.

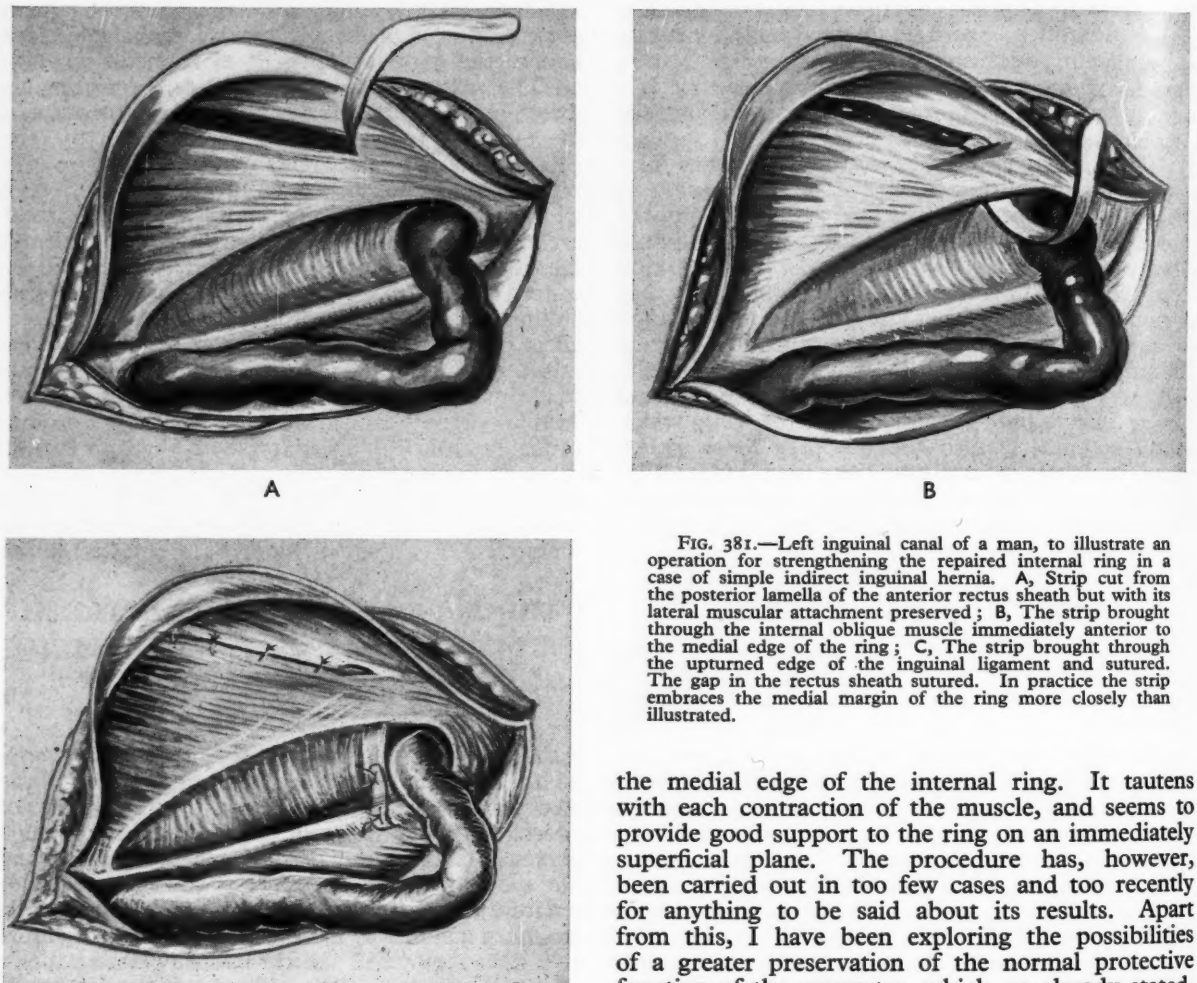

FIG. 381.—Left inguinal canal of a man, to illustrate an operation for strengthening the repaired internal ring in a case of simple indirect inguinal hernia. A, Strip cut from the posterior lamella of the anterior rectus sheath but with its lateral muscular attachment preserved; B, The strip brought through the internal oblique muscle immediately anterior to the medial edge of the ring; C, The strip brought through the upturned edge of the inguinal ligament and sutured. The gap in the rectus sheath sutured. In practice the strip embraces the medial margin of the ring more closely than illustrated.

DIRECT INGUINAL HERNIA

The first step is the reconstitution of the transverse fascia barrier either, and probably preferably, by excision of the stretched redundant portion and re-suturing, or by plication. Further support to the transversalis fascia would seem to be indicated to prevent it stretching or splitting again under a repetition of the forces causing the original hernia. To suture down the edge of the conjoint muscle and tendon to the inguinal ligament for this purpose

* My Registrar, Mr. D. W. Lacey, has recently followed up 55 cases of inguinal hernia, direct and indirect, operated on at the Middlesex Hospital under my care from 1942 to 1946 by Bloodgood's technique. Out of 47 cases traced, at the beginning of 1948 40 were found on examination to be completely satisfactory, 3 reported in writing that they were satisfactory but were not actually examined, 1 had developed an inguinal recurrence, and 3 had diffuse bulges at the linea semilunaris. Two of these cases were unaware themselves that anything was wrong, but the third had well-marked symptoms of pain and a feeling of weakness of the abdominal wall which led to further operation. At operation the bulge at the linea semilunaris weakened by the Bloodgood flap was demonstrated.

is, as already discussed, from the point of view of functional anatomy, unsound, as the procedure attempts to fix an actively contracting tissue; and as Handley and Gallie and Le Mesurier have shown, it fails in practice. The soundest principle for direct inguinal hernia would appear to be that of the ligamentous darn as devised by Handley and by Gallie, with Gallie's fascia lata sutures probably having advantages over Handley's silk. A point of practical importance is how the fascial sutures should be inserted so as to conform best with the functional anatomy of the region. If Keith's view of the shutter-like action of the conjoint muscle and tendon were correct, any system of ligamentous sutures between it and the inguinal ligament would

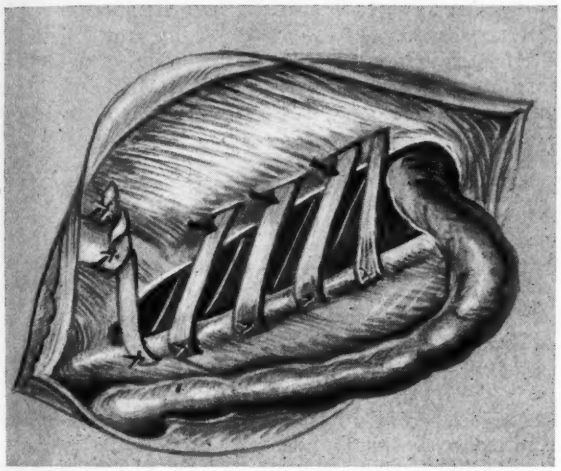

FIG. 382.—Left inguinal canal of a man, to illustrate how the ligamentous darn sutures of fascia lata, inserted from below upwards and laterally, conform with and are tautened by the predominant lateral movement of the conjoint tendon.

be of little value as they would at once become lax and inert when the muscle shutter descended to become flush with the inguinal ligament. But since the principal movement of the conjoint muscle and tendon is laterally, the fascial suture should be inserted to take advantage of this movement. And if the fascial suture is inserted with its general direction an oblique one from below upwards and laterally, its loops get well tautened at each contraction and the maximum support is thus given to the underlying transversalis fascia. (*Fig.* 382.)

CONCLUSIONS

In this paper an attempt has been made to indicate the normal functional anatomy of inguinal hernia as seen at operation, when muscular contraction is induced by faradic stimulation. As regards indirect inguinal hernia, the findings confirm those of Lytle, whose work was the stimulus and start for the investigations, in showing the sling-like protective action of the transversalis fascia at the internal ring. In addition, they show a complementary action of the muscular hook of the internal oblique lateral to the internal ring. Any operation for indirect inguinal hernia should reconstitute, and if need be strengthen, the normal mechanisms, but certainly should do nothing to interfere with them. As regards the functional anatomy of direct inguinal hernia, the shutter-like mechanism of the conjoint muscle and tendon as described by Keith does not exist, the only substantial movement being a lateral one. The operation for direct inguinal hernia should aim at reconstituting and strengthening the transversalis fascial barrier which is the main protective layer, and in so doing should take account of the functional anatomy.

Those surgeons who have worked out methods of hernial repair which in practice work and give them satisfactory results in spite of the fact that they do not conform to the principles of functional anatomy will, of course, be justified in continuing with these methods. But in general, since over a half-century of empiric methods have landed surgery in such uncertainties and dissatisfactions, the new start from the basis of functional anatomy does not seem unjustified. And just as the basis of the functional approach is the rejection of the static concept of anatomy, in the same way in the treatment of hernia a static approach must be avoided and the problem constantly re-studied in the light of the functional impairment existing in the particular hernia to be treated.

SUMMARY

1. The results of a study of the functional anatomy of inguinal hernia by stimulating the muscles at operation by a faradic current are described.

2. The sling-like protective action of the transversalis fascia at the internal ring as described by Lytle is confirmed, and a similar protective action at the lateral margin of the ring by the contractile hook of the internal oblique is described.

3. The shutter-like mechanism of the conjoint tendon as postulated by Keith does not exist, and the main protective agent for the direct inguinal area is the tautened transversalis fascia.

4. Some observations are made on the operations for indirect and direct inguinal hernia in the light of these functional anatomical findings.

I wish to acknowledge my indebtedness to Dr. Frank Howitt and his staff in the Department of Physical Medicine of the Middlesex Hospital for their co-operation and help.

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TOTAL DENUDATION OF THE PENIS

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Complete loss of the skin of the penis is such an unusual occurrence that Owens (1942), in a comprehensive survey, found reports of only 34 cases. As all these cases, with the exception of two from Australia, have been reported from either the continent of Europe or the United States of America, the author believes that accounts of four recent cases in England will be of interest. It is noteworthy that three of these recent cases and the last two from America have resulted from agricultural accidents with tractors, whereas almost all the earlier injuries arose from shafting accidents in factories. The increasing use of machinery by workers unaccustomed to the dangers of power-driven tools makes it possible that this type of accident may increase. It has become clear that all surgeons, when faced by this type of case, have had difficulty in planning treatment. In most cases their treatment has led to a penis which has been painless when erect and coitus has been possible, but this happy result has not always been achieved. A review of the methods available for treatment therefore seems opportune.

These cases arise in one of two ways: (*a*) Traumatic; (*b*) Inflammatory.

The traumatic cases are often complicated by avulsion of the skin of the scrotum and pubis; one or both testes may be torn away. It is usual to find that a fringe of foreskin, sometimes only the mucosal layer, remains, and this fringe may be used to form a partial covering for the penis. The penis itself is bared of skin and subcutaneous fat but the corpora cavernosa remain intact, being protected by the deep fascia. There is but little hæmorrhage from the wound or the divided spermatic cord.

The four cases which have been reported as of inflammatory origin have resulted from a spreading cellulitis after circumcision or from lymphogranuloma inguinale. The extreme rarity after circumcision is somewhat surprising, but Carr (1911) reports an additional case of complete loss of the scrotal skin after this minor operation.

It is remarkable that the traumatic cases seldom suffer from severe shock. Some patients have even been unaware of their injuries. Nevertheless, the need for immediate treatment is great. The majority of these patients are young and the prospects of altered urinary and sexual function causes grave mental distress. Counsellor and Palmer (1929) state that the mental change is so severe that chronic invalidism may occur, and Cottle (1924) remarks on the very great mental improvement which followed a delayed but satisfactory operation. Brown (1937), whose cases are of inflammatory origin and accordingly of long duration, remarks on the extreme mental and physical distress of his patients, while Benedict (1918) relates of a patient who became morose and even suicidal.

Historical Note.—The earliest case of which full details are available was reported by R. W. Gibbs, of Columbia, South Carolina, in 1855. Henry, a negro, had his clothes caught in factory shafting. The left testicle was torn away with the skin of the penis and scrotum. The perineal skin was sutured and the remainder of the wound healed slowly by granulation and cicatrization. He resumed work in less than four months, and six months after the accident was said to be as good a workman as ever. He had a vigorous sexual appetite and related that, although his penis was shortened, coitus produced full satisfaction.

Gibbs apparently made a full search of the literature but could only find two comparable cases. A Parisian report in 1782 gave details of a German peasant whose penis and scrotum had been torn away by a carriage; the urethra had been avulsed and the prostate bared. Healing left him with a urethral orifice behind the symphysis pubis but with full control of his urine. Baron Larrey, in 1811, had given an incomplete history of a soldier whose scrotum had been shot away, but it seems that his penis had not been damaged.

CASE REPORTS

The author is very greatly indebted to Mr. J. N. Young, of Hull, for his description of *Case* 2, and to Mr. T. V. Pearse, of Harrogate, who reports *Cases* 3 and 4.

Case 1.—J. B. P. U., a farm worker aged 47, was admitted to hospital under the care of the author on Aug. 18, 1947. He had been in charge of a tractor which was drawing a harvester. The latter was power driven by a rotating shaft from the tractor. He stopped to free a sheaf and bent over the rotating shaft. His clothes were caught on the shaft and he was brought to hospital complaining of cuts on the right arm and right thigh near the knee. He suffered from little shock and was unaware of any other injuries.

Fig. 383.—The scrotal and pubic wound has healed. The penis lies in a tunnel with the glans protruding.

When he was undressed the penis was found to be completely bared of skin except for the mucosal layer of the foreskin. The skin of the pubis had been avulsed and the right half of the scrotum was torn away, exposing both testes. At operation it was found that sufficient skin remained to reform a small scrotum just adequate to retain both testes. An incision was made in the right iliac fossa about 3 in. away from the root of the penis and a tunnel was burrowed from this incision towards the penis. The fragments of prepuce were removed and the penis was brought through the tunnel so that the glans protruded. The coronal sulcus was stitched to the edges of the skin incision and a suprapubic cystotomy was made to divert the urinary stream. (*Fig.* 383).

Progress was uneventful and on Sept. 11 the first stage of mobilization of the penis was undertaken. An incision was made parallel to the penis about 1 in. above it to raise a flap. The deep surface of the penis was freed and the flap sutured around it so that the penis was completely covered with skin but remained attached by a leaf along the line of the inguinal ligament. The bare area over the pubis was covered with a skin-graft which did not survive, presumably as the result of infection from the suprapubic fistula. (*Fig.* 384.)

Full mobilization of the penis was delayed until Oct. 23. The suprapubic catheter was removed on Nov. 9 and the fistula rapidly closed. (*Fig.* 385.)

He has now some scarring along the ventral suture line, causing the penis to be diverted to the right. Erections are painless and complete, but he is not married. The penile skin is of good texture and the glans is normally sensitive.

Case 2 (Mr. J. N. Young).—On July 30, 1947, Mr. G. was standing close to the revolving shaft of a combined harvester when the front of his trousers became entangled in the shaft. He made vigorous efforts to free himself, but before the engine could be stopped his trousers and underclothing were ripped off, together with the skin of the penis and scrotum and the right testicle and spermatic cord. He did not suffer any severe pain and was able to walk 300 yards to his home. Hæmorrhage was slight. His doctor recovered the avulsed parts and took them with the patient to the Nursing Home.

When admitted, his general condition was good. He had lost the skin of his penis, except for a fringe of prepuce, of his scrotum, and pubis. The right testis and cord had been torn away and the left testis was exposed. The avulsed skin was cleaned and the right testis, which had remained attached to it, was removed. This skin was then threaded back over the penis and scrotum as a full-thickness graft. A Foley catheter was inserted. The graft later became swollen and local patches of gangrene appeared, which had to be excised. On Sept. 3 Thiersch grafts, which took well,

FIG. 384.—The penis has been partly freed, lying attached by a leaf of skin to the groin. The granulating area above the penis is that from which the graft sloughed after elevation of an upper flap, which was wrapped around the penis.

FIG. 385.—The penis has been fully freed. The suprapubic cystotomy has healed. The raw area has epithelialized with scarring.

were applied to the raw areas of the scrotum. After circumcision on Sept. 16 he went home. When seen a month after discharge, coitus had not been possible.

Case 3 (Mr. T. V. Pearse).—On April 12, 1947, S. P., a farm labourer aged 26, leant backwards from a tractor to attend to the attachment of the plough. He toppled over and the clutch engaged. As the tractor moved backwards, the rubber tyres lacerated his scrotum. At the time he felt some burning pain, but this did not continue.

When admitted to hospital, both testes were found to be exposed in the lacerated scrotum. The penis was completely denuded, but its skin and prepuce lay beside it like the finger of an empty glove. The scrotal wound extended into the right groin and 3 in. of the right spermatic cord lay as a ragged strip unattached to the testis.

The loose portion of cord was removed; the scrotal wound was sutured. The penile skin was replaced after being cleaned.

Eight days after the injury sloughs separated from the base and left side of the penis; the right testis was a black slough; the skin of the left side of the scrotum sloughed away and it was doubtful if the left testis was viable. On May 2 the remaining right half of the foreskin was grafted on to the dorsum of the penis and Thiersch grafts were applied to the left side. The grafts took well and he went home on May 28.

On July 15 he reported a few erections without ejaculation. In December he said that he no longer bothered about coitus. A baby boy had been born to his wife while he was in hospital and he thought that the

impossibility of a daughter disappointed her more than the absence of coitus. He said that his penis sweated uncomfortably but he had no other complaints. The penis seemed small.

Case 4 (Mr. T. V. Pearse).—On April 25, 1947, A. M., a quarryman aged 52, was working a stone-crushing machine when his right hand was drawn in by the rotating teeth, which finally seized his foreskin. He suffered little shock in spite of an appalling injury to his hand; he did not mention the penile wound, although he was aware of it.

At operation it was found that the penis and glans were lying uncovered beside a complete tube of penile and preputial skin which was partly attached to the pubic skin, whence a laceration spread into the scrotum. The testes and cords were uninjured. The skin was cleaned and replaced. The penile skin survived though small superficial gangrenous patches developed on the left side.

In December the penis was essentially normal except for slight œdema of the preputial-glandular suture line. He has had normal erections but no coitus, as he has been afraid of injuring himself. When asked, he stated that his penis sweated uncomfortably.

Mr. Pearse comments that the penile skin is remarkably tenacious of life after replacement.

TREATMENT

1. Delayed Split-skin Graft after Resolution of Infection.—This has proved satisfactory, especially in cases of inflammatory origin. Brown (1937) recommends that thick grafts should be used and says that the graft must be in one piece with the edges overlapped. Byass (1943) advises that the graft should be applied firmly with a quilting stitch placed in the long axis of the penis. He points out that a circular stitch might act as a tourniquet when the penis is erected.

2. Replacement of the Avulsed Skin.—Pearse and Young both report some satisfaction, but local patches of gangrene have appeared which have sometimes required grafting secondarily.

3. Flaps from the Scrotum or Inguinal Regions.—Scrotal flaps were used by Benedict (1918), but contractures developed which compelled several secondary operations. Byass (1943) draws attention to the special value of the elasticity of the scrotal skin when the corpora cavernosa have been damaged. In traumatic cases such flaps are only rarely practicable, because the scrotum has so often been injured.

Aspinall (1918) and Robertson (1931) both found that inguinal flaps were unsatisfactory because scar contractures made erections extremely painful.

Carr (1911) and Robertson (1931) both report the re-formation of a scrotum with complete success from flaps made from the thighs.

4. Burial of the Penis in an Abdominal or Scrotal Skin Tunnel.—This method of treatment has been used by Cottle (1924), Welch (1918), and the author, and has always resulted in a penis which has been painless when erect. It has the advantage that it can be instituted at once and that the ultimate covering is of skin of good texture which will stretch.

Welch brought the penis up in the midline towards the umbilicus and allowed his patient to micturate towards his navel. The author thought that the urinary stream should be diverted by a suprapubic cystotomy, while Cottle diverted it through an external urethrotomy. Both later decided that such diversion was not only unnecessary but even inadvisable.

Brown (1937) reported a case where the penis had become embedded in the scrotum as the result of lymphogranuloma inguinale. Flaps were raised from the scrotum to wrap around the penis, with a fully satisfactory end-result.

When the penis is being freed, particular care must be taken to extend the flaps beyond the apparent essential requirements in order to secure skin to fill in the angle between the under-surface of the penis and the front of the scrotum or between the dorsum of the penis and the pubis, depending on whether the tunnel has been scrotal or abdominal.

CONCLUSIONS

1. It is desirable that definitive treatment should be instituted as early as possible.
2. The avulsed skin should be replaced unless grossly injured or contaminated.
3. If such skin is not available, the best results are secured by making abdominal or scrotal skin tunnels, liberating the penis at a secondary operation. Such tunnels should be situated as near the midline as possible.
4. It is unnecessary to divert the urinary stream.

I am very grateful to Messrs. Pearse and Young for giving me permission to record their cases and for providing the reports. It is a great pleasure to acknowledge my indebtedness to Mr. W. R. Le Fanu, Librarian of the Royal College of Surgeons, for his kindness in obtaining the report of Dr. Gibbs's original case from the Surgeon-General's Library at Washington, D.C. My thanks are also due to Mr. E. J. Pamely for his excellent photographs.

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THYMOMA*

WITH A REPORT OF 5 CASES

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EWING (1928) stated: "No group of tumours has more successfully resisted attempts at interpretation and classification than those of the thymus. The problems involved include those which complicated the embryologic and histologic study of the gland, while added difficulties arise from the comparative rarity and considerable diversity of the tumours, and from the somewhat imperfect knowledge of the general pathology of the thymus." To-day, the pathology of thymomas is still a matter of controversy and will remain so until histologists agree upon the normal constituents of the thymus.

In his inaugural dissertation to the University of Heidelberg in 1900, Grandhomme applied the term 'thymoma' to all malignant tumours of the thymus, regardless of their histological structure. It soon became apparent that Grandhomme had proposed, in effect, to group together a number of different conditions of neoplasia, using the simple criterion of their topography to indicate relationship. The classification was untenable to several authors, because of uncertainty regarding the origin of certain cell elements of the thymus. Also, confusion has arisen over which of the tumours found in the mediastinum might properly be termed true thymic tumours, but most authorities agree that this can be determined on a basis of: (*a*) Location, (*b*) Shape, (*c*) Morphology, and also (*d*) Failure to invade bone, (*e*) Tendency to spread by direct extension to the surrounding pleura and pericardium, and (*f*) Failure to metastasize below the diaphragm (Foot, 1920).

Heuer and Andrus (1940) indicated that the malignant thymomas grew anteriorly, with involvement of the sternum at times; and posteriorly, surrounding the mediastinal structure; but that distant metastases were uncommon. The tumour is usually hard and nodular, but sometimes soft and vascular.

Crosby (1932) stated that both sarcomas and carcinomas not only involved the adjacent organs, including the sternum, myocardium, thyroid, and trachea, but metastasized widely—even below the diaphragm. These authors indicated that the symptoms of malignant thymomas were predominantly thoracic, although late extrathoracic signs might appear. The course was described as rapid in malignant types and the patient usually died of suffocation. Decker (1935) wrote that in the case of malignant tumour the usual signs and symptoms of mediastinal tumour, such as cough, pain, dyspnœa, and hæmorrhage, were present, and that occasionally the cervical glands were enlarged or there was a swelling in the neck or upper anterior chest. The signs may be fairly silent and evidenced only by metastases. The duration of life after the onset of symptoms was usually between 1 year and 18 months. Crosby (1932) found the most common complications of malignant thymic tumours to be pleurisy and pericarditis, with effusion, obliteration of the vessels of the neck, and obstruction of the œsophagus and the trachea.

Andrus and Foot (1937) classified thymomas into two types, non-malignant and malignant. They divided malignant thymomas into seven subgroups:—

1. *Thymocytic or Lymphocytoid Type.*—These are composed of small round cells with deeply staining nucleus. Hassall's corpuscles may or may not be present.

2. *Large-celled or Lymphoblastic Type.*—These are made up of large cells varying from round to ovoid, resembling lymphoblasts or primitive thymic reticulum cells. Thymic corpuscles may or may not be present.

3. *Thymic Reticulum-cell Type.*—Cells closely resemble the entodermal thymic reticulum cell, and this group is probably the largest and most frequently occurring of the malignant thymomas.

4. *Perithelial Type.*—These definitely show perithelial arrangement of radially directed fusiform cells about their vessels and are quite characteristic in appearance. Thymic corpuscles do not play an important role in these tumours.

5. *Granulomatous Type.*—The picture is that of Hodgkin's granuloma located in the thymus or its site.

6. *Epithelial or Carcinomatous Type.*—Occur in elderly subjects and resemble epidermoid carcinoma, as they are composed of innumerable thymic corpuscles in all stages of development and degeneration. The thymic reticular cells may form radiating cords from such 'pearls' which sometimes have a duct-like arrangement, with a liberal admixture of lymphocytoid elements. This appearance may shift the picture toward that of lympho-epithelioma of Schmincke.

7. *Teratoid Type.*—All the elements of the normal thymus are found to be undergoing abnormal proliferation or they may predominate in one or two. Duct- or gland-like structure may be found, or even solid medullary plugs of pale, rather delicate, epithelium.

Lympho-epitheliomas of the thymus are much less often malignant than are the primary lympho-epitheliomas of the tonsils, pharynx, and nasopharynx (Cappell, 1934; Harvey, Dawson, and Innes, 1937). The thymic lympho-epitheliomas seem, in some cases, to exert an endocrine effect, and are specially related to myasthenia gravis. It seems that in very rare cases malignant thymomas may, by some

* Received for publication February, 1948.

unknown process, disturb the endocrine balance in such a way as to give rise to symptoms somewhat resembling Cushing's syndrome (Leyton, Turnbull, and Bralton, 1931). Weber and Blum (1942) estimated that in something like 55 per cent of cases of myasthenia gravis, hypertrophy or primary tumour (lympho-epithelioma) of the thymus has been present, but in reality the percentage is probably considerably higher, for in many cases thymus or thymic tumour has not been sufficiently looked for. On the other hand, myasthenic symptoms may have been overlooked in some cases of thymic tumour in surgical wards.

The diagnosis of thymoma may be confused with cardiac aneurysm, pericardial tumour and cysts, mediastinal lymphogranuloma, mediastinal gumma, mediastinal phlegmon, and congenital dilatation of the pulmonary artery. Benign tumours of the thymus cast a circumscribed shadow in the anterior mediastinum between the sternum and pericardium (Heuer and Andrus, 1940). Blalock (1941) drew attention to the value of lateral radiographs in demonstrating tumours and enlargement of the thymus.

HISTORICAL SURVEY OF THYMOMA
(*Tables I, II*)

In 1901 Weigert found at necropsy a tumour of the thymus in a patient who had died of myasthenia gravis. However, no illustrations accompany this report, and therefore we cannot be certain as to the exact nature of the tumour.

Meggendorfer (1908) recorded a case in which myasthenia gravis was associated with a malignant thymic growth. Bell (1917) made a comprehensive study of myasthenia gravis with an associated thymic

Table I.—THE THYMOMA CALENDAR

YEAR	AUTHOR	CASE No.	OPERATION	AUTOPSY	MYASTHENIA GRAVIS	PATHOLOGY
1901	Weigert	1	No	Yes	Yes	?
1908	Meggendorfer	2	No	Yes	Yes	Malignant
1913	Schumacher and Roth	3	Yes (successful)	No	Yes	Enlarged thymus
1917	Bell	13	No	10	Yes	?
1917	Haberer	14	Yes (successful)	No	Yes	Involuted
1932	Crosby	166				
1934	Brem and Wechsler	168	No	Yes	Yes	Benign
1935	Decker	208				
1937	Adler	209	Yes (died)	No	Yes	Benign
1937	Obiditsch	210	Yes (died)	—	Yes	Benign
1937	Obiditsch	219		9	3	?
1937	Andrus and Foot	220	Yes (successful)	No	No	Benign, 2235 g.
1939	Blalock and others	251	Yes	Yes	31	?
1939	Blalock and others	252	Yes	No	Yes	?
1939	Duvoir and others	253	—	Yes	Yes	Benign
1941	Aronson	254	No	Yes	Yes	Benign
1941	Lafferty	255				Lymphosarcoma
1941	Hellwig	261	Biopsy (1)	5	No	Malignant
1942	Poer	262	Yes	No	Yes	Perithelioma
1942	Weber and Blum	263	No	Yes	No	Benign
1942	Turnbull	264	Yes	No	Yes	Lymphosarcoma
1942	Campbell and others	266	Yes (2)	—	Yes	Benign
1943	Aufses	267	Yes	No	No	Transitional-cell carcinoma
1943	Haynes	268	No	Yes	Yes	Benign
1943	Roberts	269	No	No	No	? Malignant
1943	Homburger	272	No	3	No	Malignant
1943	Clagett	277	Yes	—	Yes	?
1943	Bradshaw	278	Yes	—	Yes	Benign
1944	Weber and Wohl	279	No	No	No	? Malignant
1944	Tribedi	281	No	Yes	No	Malignant
1945	Murray and McDonald	284	No	3	No	Malignant
1945	Le Coeur and Mathey	285	Yes	Yes	No	Malignant
1946	Wilson and Pritchard	288	No	3	No	Malignant
1946	Keynes	295	Yes	1	Yes	Malignant (1), Benign (6)
1947	Barrett	296	Yes	?	Yes	? Malignant

Table II.—THE MALIGNANT THYMOMA CALENDAR

YEAR	AUTHOR	CASE No.	OPERATION	AUTOPSY	MYASTHENIA GRAVIS	PATHOLOGY
1940	Heuer and Andrus	230	Yes	Yes	?	
1941	Lafferty	231				Lymphosarcoma
1941	Hellwig	237	Biopsy	5	No	Two cases of Hodgkin's disease not included
1942	Poer	238	Yes (successful)	No	Yes	Perithelioma
1942	Turnbull	239	Yes (successful)	No	Yes	Lymphosarcoma
1943	Aufses	240	Yes (partial)	No	No	Transitional-cell carcinoma
1943	Roberts	241	No	No	No	
1943	Homburger	244	No	3	No	
1944	Weber and Wohl	245	No	No	No	
1944	Tribedi	247	No	2	No	
1945	Murray and McDonald	250	No	3	No	
1945	Wilson and Pritchard	253	No	3	No	
1945	Le Coeur and Mathey	254	Yes	Yes	No	Carcinoma
1946	Keynes	255	Yes	Yes	Yes	No secondaries

tumour. He found published reports of 56 autopsied cases of this disease. In 10 of these there was a tumour of the thymus.

Foot (1926) observed that malignant thymomas are distinctly rare, less than a hundred having been described to date. Crosby (1932) was able to find a total of 166 thymic tumours, 144 of which he tabulated, and added 1 case of his own. The review of malignant tumours of the thymus was brought up to date by Decker in 1935, at which time the total number was 208. Norris (1938) collected and tabulated data on 35 cases of myasthenia gravis with an associated thymic involvement in about 50 per cent of the cases. Such changes he regarded as conditions of extreme epithelial hyperplasia. When hyperplasia is extreme, a localized and at times encapsulated, tumour-like mass is formed.

The first attempt at surgical removal of a thymoma was by Sauerbruch.

In 1911 he had successfully removed a persistent thymus associated with myasthenia using a transverse incision in the neck just above the sternum (Schumacher and Roth, 1913), but it was not until much later (Adler, 1937) that he removed a thymoma. The tumour was a benign one, the size of a child's head, but the patient died eight days later from mediastinitis. His second case (Obiditsch, 1937) had a tumour the size of a man's fist. This tumour was also removed through the neck but the patient died three days later of a streptococcal infection. Both these patients were suffering from myasthenia gravis.

Obiditsch reported 9 thymic tumours, 3 of which were associated with myasthenia gravis. He expressed the belief that the thymic tumours associated with myasthenia gravis were made up of overwhelming numbers of small round cells.

Andrus and Foot (1937) successfully removed the largest thymic tumour recorded. It weighed 2235 g., and although it was of the non-malignant variety it was unaccompanied by myasthenia gravis, unless the asthenia described in the history was due to this condition and not to the pressure effects of the tumour.

Blalock and his associates (1939) reviewed the literature up to 1939 and found 110 autopsies and operations on patients suffering from myasthenia gravis. In 31 cases tumours of the thymus were present. They report the successful removal of a benign cystic tumour of the thymus in a patient suffering from myasthenia gravis. This tumour had been treated with high-voltage therapy and its pathology is obscure. The patient was alive and well three years after the operation.

Heuer and Andrus (1940) were able to collect 230 cases of malignant thymomas, including the previous reviews, which included lymphosarcoma, carcinoma, sarcoma, and granulomatous and teratoid tumours.

Aronson (1941) reported the death of a patient with myasthenia gravis, which occurred 24 hours after irradiation of a thymic tumour. In 1941 Lafferty reported a case of primary lymphosarcoma of the thymus gland, and Hellwig (1941) reviewed 8 cases of malignant thymomas. In August, 1941, Poer and Seaman (1943) successfully removed a malignant tumour of the thymus (perithelioma) in a case of myasthenia gravis. Five months later the patient was back at work without any symptoms of myasthenia and requiring no treatment. Weber and Blum (1942) reported the autopsy findings of a case of benign lympho-epithelioma in a patient with a marked general asthenia, but no definite characteristic feature of myasthenia gravis. Turnbull (1942) successfully removed a malignant thymoma (lymphosarcoma) in a patient with myasthenia gravis. There was no improvement of the myasthenia gravis. Fonts Abreu (1943) reported a case of carcinoma of the thymus, and Haynes (1943) reported the autopsy findings of a benign thymoma in a case of myasthenia gravis.

Aufses (1943) completed the follow-up report on a transitional-cell carcinoma of the thymus in a child, which had been treated by radiotherapy and partial surgical removal. The child died from recurrences one year after the commencement of treatment.

Duany and Castellanos (1943) collected 100 cases of tumours of the thymus accompanied by leukæmia. Although the numerical breakdown is not made, some of these have occurred as primary tumours with a blood-picture altering secondarily.

Homburger (1943) found 3 cases of cancerous thymoma accompanied by metastases among 6000 autopsies. Clagett and Eaton (1943) removed 4 thymic tumours in myasthenia gravis and added Dr. Harrington's case. Two of their own cases have remained well and in two others the course was unaffected. The fifth was too early to evaluate.

Weber and Wohl (1944) described a new syndrome—macrogenitosomia of 'juvenile Hercules type' with tumour in the superior mediastinum. This tumour is probably a malignant thymoma. They refer to a case shown at the meeting of the Royal Society of Medicine (Clinical Section) in December, 1943, by Mr. J. E. H. Roberts—a boy, aged 16, with abnormally small testes and bilateral gynæcomastia. The boy had been treated by deep X rays for what was probably a large, rapidly growing (malignant) primary thymic tumour mainly in the anterior mediastinum, and causing alarming pressure symptoms. As a result of the treatment, the tumour had disappeared.

Tribedi (1944) reported the autopsy findings of two cases of malignant thymoma in Indian patients.

Murray and McDonald (1945) reviewed 13 cases of tumours of the thymus associated with myasthenia gravis. Three of these tumours were undoubtedly malignant thymomas, as metastases were noted in two instances and direct extension into the vena cava in one instance.

Le Coeur and Mathey (1945) operated on a malignant thymoma, which was diagnosed preoperatively as a dermoid cyst of the anterior mediastinum. Owing to the excessive bleeding, they were not able to remove the tumour. The patient died one hour after the operation.

Wilson and Pritchard (1945) found 11 necropsied cases of malignant thymomas in a total of 7500 autopsies over a period of 25 years. Six of these tumours had invaded the lung, and the possibility of bronchial carcinoma had not been excluded. The seventh case was associated with acute myelogenous leukæmia and the thymus was probably

affected secondarily. The eighth case, described as malignant thymoma of the Hodgkin variety with metastases to the cervical, axillary, and gastro-hepatic nodes, may be a case of Hodgkin's disease secondarily involving the thymus. The remaining three tumours fit into the category of malignant thymomas.

Geoffrey Keynes (1946, a, b) found 7 thymomas in 63 cases operated on for myasthenia gravis. One was infiltrating the pericardium, pleura, and lungs, and was judged to be ineradicable. The patient died soon after operation, and was found at autopsy to have compression of a main bronchus.

Barrett (1947) found 1 thymoma in 10 cases operated on for myasthenia gravis. The patient died soon after the operation.

Up to date, 296 thymomas have been traced in the literature, 255 being malignant. Benign thymomas occur more commonly than malignant thymomas in conjunction with myasthenia gravis.

Our own experience consists of 5 cases, the history and clinical course of which are briefly set out, together with the relevant radiographs.

In 2 cases the tumour was removed, in one with a fatal result; in 1 case the chest was explored and the tumour found to be ineradicable; and in the other 2 cases high-voltage therapy only was given.

DIAGNOSIS

The clinical symptoms of a thymic tumour are few at first, and unless mass radiography is carried out their presence is not suspected until lymph-node enlargement is seen or symptoms of intra-thoracic pressure develop. In about half the cases symptoms of myasthenia gravis are present and lead to radiographic examination.

The radiograph shows a shadow which, in the anteroposterior view, occupies the mediastinum to one or other side of the heart shadow, and on a lateral view occupies the superior mediastinum above the heart. It has to be differentiated from other mediastinal masses, especially lymphadenoma, cardiac aneurysm and pericardial cysts, mediastinal granulomas and teratomas, and congenital dilatation of the pulmonary artery.

TREATMENT

Surgical removal is the only sure method of cure. This may be difficult and dangerous, as the tumour does not remain encapsulated, and it may be adherent to large blood-vessels and embedded in a vascular mass of adhesions. (*Tables III, IV.*)

Table III.—NUMBER OF THYMOMAS REMOVED SURGICALLY IN MYASTHENIA GRAVIS

Total	29
Thompson (1947)	15 (excludes Sauerbruch's first case)
Keynes (1946)	7
Barrett (1947)	1
Reid (1945 and 1948)	2
Viets (1946)	5

Table IV.—RESULT OF SURGERY FOR THYMOMA IN MYASTHENIA GRAVIS

Number of tumours assayed	18
Benefit	9
No benefit	3
Too early to classify	1
Deaths (post-operative)	5

The surgical approach may be through the sternum, which is divided in the midline by a circular saw and widely retracted to expose the anterior mediastinum. This approach has been used by us in one case of malignant tumour and is the usual approach for removal of a persistent thymus. It has the advantage that the pleura is not opened, but it is suitable only for small tumours. Myasthenic patients have a very much smaller margin of respiratory reserve than other patients, as well as a tendency to excessive secretion of mucus, and even a temporary collapse of the lung is to be avoided if possible.

For large tumours the posterolateral transpleural approach gives adequate exposure to all parts of the hemithorax. The patient is fixed on his side, the fifth or sixth rib is excised, or the thorax is opened through an intercostal space. To increase the size of the exposure, a rib above or below the original incision may be divided behind its angle.

Other approaches have been described, such as the anterolateral (Campbell, Fradkin, and Lipetz, 1942), where a horizontal incision is made over the third rib from the left sternal border to the anterior axillary line. The third rib is resected subperiosteally from the sternal junction and about 7 in. of rib removed, together with some of the sternal margin. The pleura is opened and the wound retracted.

In our opinion, this approach does not give such a satisfactory exposure of the hemithorax.

CASE REPORTS

Case 1.—A. W. B., a male, aged 29, complained of a feeling of general weakness and difficulty with speech in February, 1945. This was followed by ptosis of the eyes, increased difficulty with speech and swallowing, and weakness of the arms, which definitely grew worse as the day wore on. The picture was classically that of myasthenia gravis. He responded well to prostigmin, but the response, at first good, wore off quickly, as is characteristic of such cases. As he was apparently getting worse and requiring more and more prostigmin, he was admitted to the hospital for thymectomy.

Radiography showed a characteristic picture of a large tumour in the anterior mediastinum (*Figs.* 386, 387).

A diagnosis of thymoma associated with myasthenia gravis was made and operation advised.

AT OPERATION (Sept. 16).—The sternum was divided in the midline to expose the anterior mediastinum. A partly cystic tumour 4 × 2 × 2 in., extending from the anterior mediastinum across the root of the left lung to the pericardium was discovered and removed. The dissection was difficult, owing to adherence of the tumour to the structures on which it was lying. A mass of tissue resembling thymus lying to the right of the tumour was also removed (*Fig.* 388).

Microscopy showed the appearance of a large reticulum-celled carcinoma (*Fig.* 389).

Two days later the patient died.

AT POST-MORTEM EXAMINATION.—The left lung was found to be collapsed, but the bronchi were patent. There was a considerable amount of blood in the pleural cavity, but no source of the hæmorrhage could be found.

The right lung was not collapsed, but there was some œdema. The bronchi were patent.

The heart was normal and the thyroid gland was normal.

Histological examination proved the tissue from the thymic region to be thymus. It weighed 4·5 g.

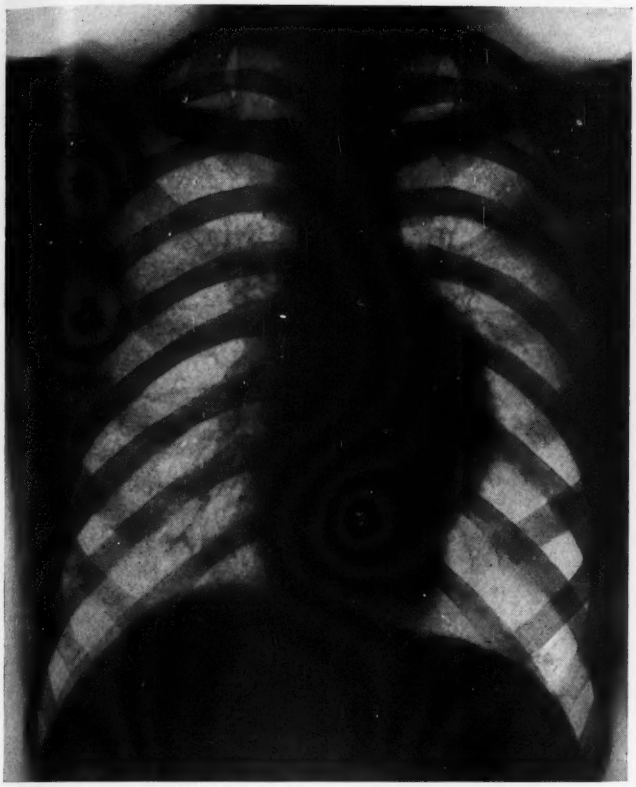

FIG. 386.—*Case* 1 (*A. W. B.*). Postero-anterior radiograph of chest showing well-marked mediastinal shadow above and to the left of heart shadow.

FIG. 387.—*Case* 1 (*A. W. B.*). Lateral radiograph showing shadow in anterior mediastinum above the heart shadow.

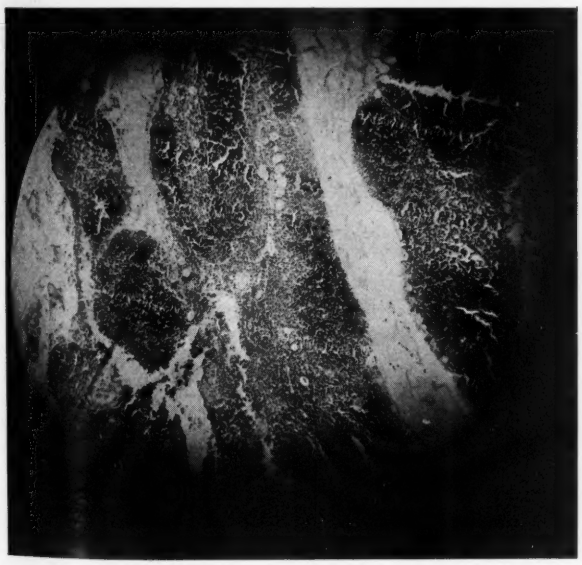

FIG. 388.—*Case* 1 (*A. W. B.*). *Thymus gland,* showing almost a normal degree of age involution with the lobules separated by large amounts of fatty tissue. The differentiation of cortex and medulla remains distinct. In the medulla small circumscribed follicles composed of reticulum cells are present. Hassall's corpuscles are well defined, some of which show early degenerative changes. There is no evidence of malignancy in this tissue. (*Dr. Winston Evans.*)

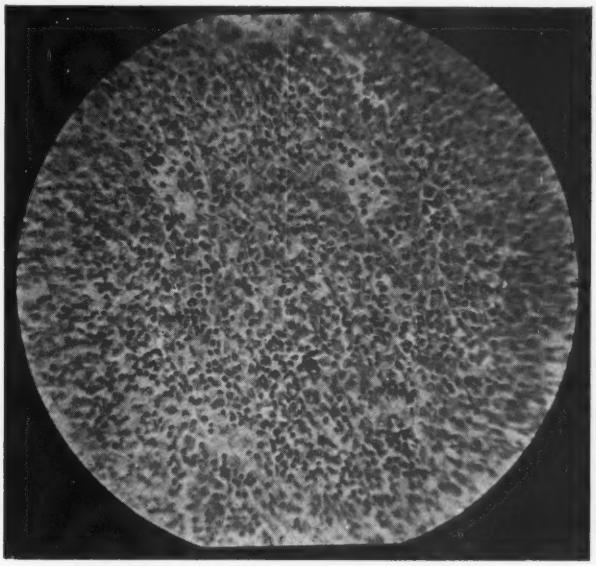

FIG. 389.—*Case* 1 (*A. W. B.*). *Growth overlying heart—malignant thymoma.* This is a diffuse large reticulum-cell thymic carcinoma. Intermingled in a fairly uniform manner among the reticulum cells are well-formed lymphocytes (giving the general impression of a 'lympho-epithelioma'). (× 200.) (*Dr. Winston Evans.*)

The larger tumour from below the thymus proved microscopically to be a homogeneous tumour composed of small lymphocytes and larger reticular cells. It appeared to be exactly similar to the primary thymomas described by Turnbull and Ewing.

Case 2.—B. A. W., a male, aged 47, was admitted to hospital in February, 1946, complaining of a feeling of pressure in the neck and chest for seven months and a swelling on the chest for four months. Three weeks before admission, he experienced soreness at a point

behind the sternum rather below the swelling and also a sensation of swelling in the neck, face, and eyes brought about by lying down or stooping. On waking up in the morning, his eyelids were puffy. There was no headache or vomiting. His vision had become poor in the last two years. From August to December, 1944, the patient experienced daily bouts of dizziness and diplopia from 3 to 7 p.m. The first attack was associated with vomiting. Throughout this period, his balance was also very poor. Dysphagia and dysarthria were absent.

for four years. The swelling had decreased in size after taking thyroid extract, but a small mass persisted. There was slight pain in the neck. She had noticed that her face became cyanosed on exertion and when she stooped her face became congested, and a "dizzy spell" occurred. Dyspnœa was absent even on exertion, but she found it a great effort even to walk. Her friends had noticed that the left upper eyelid tended to droop, especially at the end of the day. Palpitations occurred periodically, especially on exertion. Recently

FIG. 390.—*Case* 3 (*M. W.*). Postero-anterior radiograph of chest showing well-marked shadow in the upper mediastinum extending outwards from the great vessels.

FIG. 391.—*Case* 3 (*M. W.*). Lateral radiograph showing shadow in anterior mediastinum above the heart shadow.

ON EXAMINATION.—A rounded, firm, fixed, non-pulsatile swelling $2\frac{1}{2} \times 4$ in. was situated on the right chest, extending from the sternoclavicular joint to the fourth rib below, and from the left sternal border to the right nipple line. There were distended veins on the middle of the chest anteriorly and œdema of both lower eyelids. Slight pitting œdema of both arms, and diplopia was present at the extreme lateral limits of vision.

Radiography showed a characteristic opacity in the anterior mediastinum.

A biopsy of the tumour showed the microscopical appearance of a reticulum-celled carcinoma of the large-celled type with degenerate Hassall's corpuscles.

TREATMENT.—High-voltage therapy was instituted in April and produced marked improvement in his symptoms and disappearance of the swelling on his chest within four months.

When reviewed early in 1947 and again in January, 1948, the patient was well and had no symptoms. Radiography showed no evidence of pulmonary pathology.

Case 3.—M. W., a housewife, aged 50, was admitted to the Liverpool Royal Infirmary on Sept. 10, 1946, complaining of a swelling in the right side of the neck she had lost her voice, but this had improved, leaving her hoarse. During the last two years she had lost 2 st. in weight, although her appetite was good and there was no indigestion and no nervousness.

ON EXAMINATION.—There was marked dilatation of the veins on the upper chest, arms, and neck.

On stooping, there was cyanosis of the face and further congestion of the veins of the neck.

On percussion of the chest, dullness could be demonstrated for about 2 in. on either side of the manubrium sterni, but no other abnormalities were present, except slight displacement of the apex beat to the left.

Radiography, in August, 1946, showed a large mass in the superior mediastinum, which appeared to be situated anteriorly and to be displacing the trachea posteriorly (*Figs.* 390, 391).

Bronchoscopy showed the trachea and carina to be normal. The right bronchus was concentrically constricted and the left bronchus flattened from before backwards, but otherwise normal.

After a test dose of curare had been given, breathing ceased, but recommenced after applying artificial respiration and the exhibition of atropine gr. $\frac{1}{50}$ and prostigmin 5 mg. intravenously.

One hour later, atropine and prostigmin had to be repeated.

The patient's reaction to curare confirmed the clinical impression that she was suffering from myasthenia gravis.

TREATMENT.—We considered that her general condition did not warrant major surgery and high-voltage therapy was instituted. As a result of this treatment, her condition improved greatly and the symptoms of mediastinal obstruction disappeared, although she complained of some breathlessness.

OPERATION (July 8).—The chest was explored by a transpleural approach through a long incision made over the right fourth rib. A large mass, about the size of a goose's egg, displacing the heart downwards and extending upwards on to the great vessels, was seen in the anterior mediastinum. The pleura was incised in the sulcus between the thoracic wall and the tumour. On reflecting the pleura, there was a great deal of oozing, which was controlled with difficulty. The tumour appeared closely adherent to the superior vena cava, but completely separate from the lungs. Further mobilization was hampered by bleeding and fixity of the tumour and operative procedures were abandoned after having taken a piece of tumour for section.

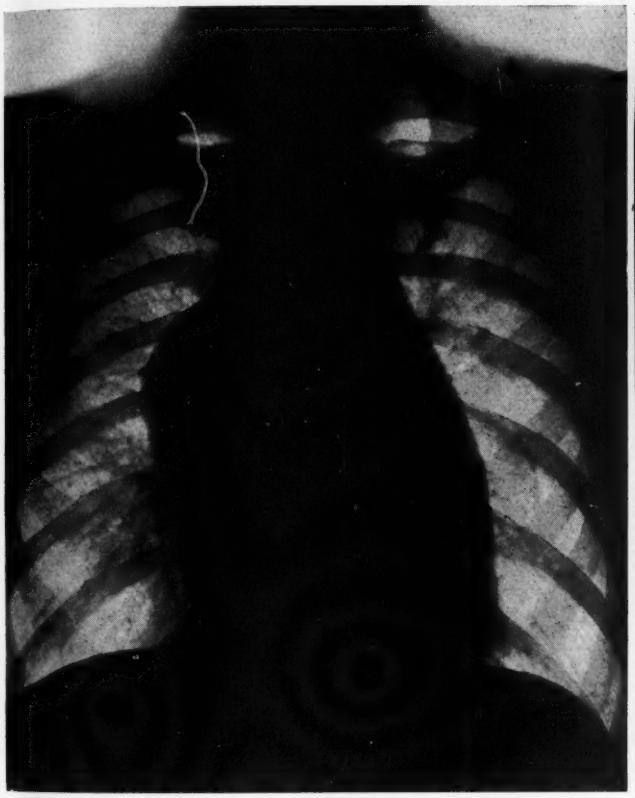

FIG. 392.—*Case* 4 (*L. R.*). Postero-anterior radiograph showing large rounded shadow extending outwards from the left side of the upper part of the heart shadow.

FIG. 393.—*Case* 4 (*L. R.*). Lateral radiograph showing shadow in anterior mediastinum above the heart shadow.

Radiography fourteen months later showed that the mediastinal mass had become very much smaller, with only evidence of fibrosis in the right upper zone and a raised diaphragm.

Case 4.—L. R., a male, aged 33, was admitted to hospital in May, 1947, for investigation of a shadow in the right upper chest, which was found during mass radiography examination. There was nothing relevant in the family history and he had had no serious illnesses.

Just previous to admission, he gave a history of having had an attack of "gastric flu". There had been no cough or undue breathlessness, but he thought that exercise produced dyspnœa more easily than before his influenza.

ON EXAMINATION.—There were no abnormal physical signs, except an old Erb's palsy with slight wasting of the left pectoral muscles.

The blood-picture and other general investigations were normal.

Radiography showed a large, rounded shadow lying anteriorly in the mediastinum continuous with the cardiac outline, but showing only transmitted pulsation (*Figs.* 392, 393).

Microscopy showed the tumour to be a reticulum-celled carcinoma of the small round-celled type, the arrangement conforming to the description of thymomas.

POST-OPERATIVE TREATMENT.—High-voltage therapy was instituted as soon as the wound was healed, and produced such marked improvement that the shadow of the tumour was hardly visible in the radiographs.

When reviewed three months after operation, he had gained a stone in weight and had no untoward symptoms, except slight breathlessness on exertion. We proposed, therefore, to re-explore the chest and remove the vestiges of the tumour, because we feared inevitable recurrence in spite of high-voltage therapy.

On readmission to hospital a week later, however, a further radiograph revealed that a nodular shadow had appeared in the right (contralateral) hilum of the lung (*Figs.* 394, 395). As this was considered to be due to a glandular metastasis, operation was not undertaken.

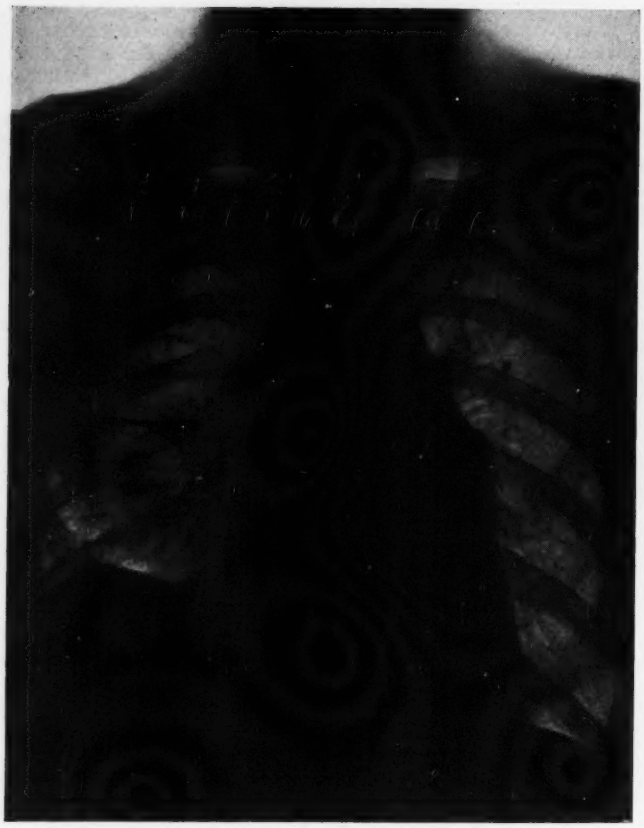

FIG. 394.—*Case* 4 (*L. R.*). Postero-anterior radiograph showing disappearance of original shadow on R. (after exploratory operation and high-voltage X-ray therapy). There is now some pulmonary fibrosis and a diaphragmatic adhesion causing 'peaking'. On the contralateral side a rounded nodule has appeared in the hilum of the lung due to a metastasis.

FIG. 395.—*Case* 4 (*L. R.*). Lateral radiograph of right side of chest showing dense shadow at hilum of lung. (This radiograph should be reversed.)

Case 5.—J. S., a male, aged 53.

In 1940 he first noticed loss of voice (he was a bass singer). Soon afterwards his voice became nasal after speaking. Dysphagia and diplopia then developed and he gradually lost power in his skeletal muscles and became bed-ridden. He was fed rectally and given prostigmin.

There was gradual improvement over a month, so that he was able to return to work as a clerk.

He relapsed in 1943, but by increasing the prostigmin to four tablets daily (30 mg.) he was able to return to work again.

In May, 1948, he became weaker in spite of increasing doses of prostigmin and was admitted to the Royal Infirmary, where he was given two tablets (30 mg.) of prostigmin every two hours.

Radiographs of the chest showed no evidence of pulmonary pathology.

OPERATION (June 9).—The mediastinum was explored after dividing the sternum in the midline with a pneumatic circular saw.

A hard, rounded, lobulated tumour, the size of a hen's egg, was discovered lying over the root of the aorta. The tumour was seen to be infiltrating the right pleura and the adjacent portion of the lung, so that the right pleura had to be opened before the tumour could be freed and delivered.

The condition of the patient throughout the operation was satisfactory and he made a good recovery.

PATHOLOGICAL REPORT.—The tissue consists of large masses of lymphoid tissue without any trace of Hassall's corpuscles or lymphoid follicles; the masses are separated by rather dense fibrous tissue. The lymphocytes, which form practically all the tissue, show no mitoses. The reticulum cells are, however, prominent and in many areas form packed groups. There is no question at all that these are reticulum cells; they are certainly not epithelioid cells.

PROGRESS.—On Aug. 5 he reported, saying he could talk and eat without difficulty, but there was slight weakness in the hands.

He is taking 30 mg. of prostigmin t.d.s. by mouth and 2·5 mg. at night intramuscularly. He works in his garden and visits the cinema, but has not returned to his occupation as a clerk.

SUMMARY

A complete historical survey of thymomas together with an appraisal of their pathological features is given.

The diagnosis is discussed.

A brief outline of the surgical approach for the removal of thymomas is described.

Thirty thymomas associated with myasthenia gravis have been removed by operation.

Our personal experiences with 5 cases of thymomas is detailed.

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THE ANAL INTERMUSCULAR SEPTUM

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THE term 'anal intermuscular septum' has become firmly established in surgical literature (Milligan and Morgan, 1934; Milligan, 1942; Whitney, 1943), and is applied to an annular band of fascia situated between the internal sphincter and the subcutaneous portion of the external anal sphincter. This septum, according to Milligan and Morgan (1934), is attached to the skin of the anus at the mucocutaneous junction, and forms the main distal insertion of the longitudinal muscle coat of the anal canal together with certain of the fibres of levator ani.

As this account is at variance with the teaching of many of the old masters of anatomy (Béraud, 1858; Holl, 1896; Kohlrausch, 1854; Laimer, 1884; Robin and Cadiat, 1874; Roux, 1881; Rudinger, 1878), the matter has been reinvestigated by macroscopical and microscopical examination of fresh human material.

Twenty specimens, 12 adult and 8 fœtal, were studied.

HISTORICAL REVIEW

The old anatomists regarded the rectum as a hollow muscular tube discharging at the surface through the anus and guarded by a sphincter muscle. Subdivisions of the external sphincter were described, the grouping of this muscle into three distinct components being proposed by Santorini (1775). The first hint of a more complex arrangement of the anal musculature we owe to Cruveilhier (1852), who observed two important details: (1) the inseparable union between levator ani and the deep part of the external sphincter; and (2) the accession of fibres to the longitudinal muscle coat of the rectum from the levator ani.

A number of articles by continental anatomists now appeared in which the anal musculature was described in great detail and figured with commendable accuracy. Thus Kohlrausch (1854) gave an illustration in which the longitudinal fibres of the rectum were shown to end in a brush-like diffusion that passed between the bundles of the external sphincter. Béraud (1858) traced these longitudinal fibres through the sphincteric layers, and stated that they, together with fibres of levator ani, were inserted into the skin. Robin and Cadiat (1874) confirmed this description, with the addition that the longitudinal fasciculi contained many elastic fibres. But no mention was made by these writers of longitudinal fibres passing between the internal and external sphincters in that situation now commonly regarded as occupied by the anal intermuscular septum, although Rudinger (1878) did make specific reference to an arch of longitudinal fibres passing round the distal border of the internal sphincter. These were shown as a thin stratum, the great majority of the fibres traversing the external sphincter to end in the fat. Rudinger drew attention to two further details: (1) the presence of a thick

muscularis mucosæ which extended to the distal border of the internal sphincter, and (2) fibres of the muscularis mucosæ were shown passing through the internal sphincter to blend with the longitudinal coat. Roux (1881) restated these facts with a somewhat different interpretation. The longitudinal coat he described as fanning out like a paint-brush to end partly among the fibres of the sphincters and partly in the skin. The deeper fibres of the longitudinal layer traversed the upper bundles of the internal sphincter and joined the muscularis mucosæ. The lowest of these offsets he described as a loop enclosing the distal border of the internal sphincter. Laimer (1884) investigated the union between the levator ani and the longitudinal muscle coat of the rectum. He regarded the levator as sending some fibres to blend with the circular coat where they terminated within the substance of the internal sphincter.

To Holl (1896) may be attributed the first illustration of an anal intermuscular septum, although the structure was not mentioned as such. He described the termination of the longitudinal coat as an intermixture of fibro-elastic and smooth muscle tissue, which divided distally into three laminæ, the most medial passing between the external sphincter and the rectal wall. Symington (1889) concurred with the statement by Laimer (1884) that some of the fibres of levator ani blend with the external sphincter, and to a lesser degree with the internal sphincter. Poirier (1901), in a detailed account, described the fusion of the longitudinal muscle of the rectum with the deep fibres of levator ani. The voluntary bundles of the latter disappeared and the conjoint aponeurosis so formed divided into a number of concentric bundles which pierced the external sphincter and terminated in the deeper layer of the dermis. The innermost of these bundles were described as passing between the internal and external sphincter muscles. Zuckerkandl (1904) figured the muscularis mucosæ blending distally with the internal sphincter and the cutis. The longitudinal muscle coat was shown dividing into ten or more fasciculi that traversed the external sphincter. F. P. Johnson (1914) quoted Béraud and Roux, and agreed that the longitudinal coat fanned out distally to form septa separating the bundles of the external sphincter.

PRESENT-DAY CONCEPTS

H. A. Harris (1928) referred to the comparative anatomy of the anal musculature. He drew attention to the manner in which the external sphincter overlaps both the internal sphincter and the levator ani at its insertion in man. The longitudinal muscle fades away distally and is poorly developed at the white line where in man the levator is " markedly fleshy tendinous and tendinous ". Abel (1932) mentioned the longitudinal coat in his article on the pecten band. The fused longitudinal and levator muscles were described as passing down in two parts: (1) through the external sphincter, dividing the latter into superficial and deep components; and (2) lateral to the external sphincter, forming an external capsule for this muscle.

Milligan and Morgan (1934) laid the foundations of modern surgical teaching of the anatomy of the region. They described the anal intermuscular septum as an annular band of fascia separating the internal sphincter from the subcutaneous external sphincter. The longitudinal muscle coat became fibrous at the level of the upper end of the anal canal where it blended with the puborectalis and the deep fibres of the external sphincter. It terminated by dividing into fibromuscular septa, some of which separated and ensheathed the parts of the external sphincter, and these septa finally faded away in the ischiorectal fat. The remainder of the longitudinal muscle coat ended by passing between the internal sphincter and the upper border of the subcutaneous external sphincter to form the anal intermuscular septum. The latter was attached by a narrow or sometimes by a broad ring to the skin of the anus in the region of the mucocutaneous junction.

The majority of subsequent writers have accepted the above concept of an anal intermuscular septum that affords the main lower attachment of the conjoint longitudinal muscle. However, Levy (1936) described the longitudinal layer as a fibro-elastic structure arranged distally in concentric tiers attached to the anal lining and to the deep surface of the skin. Daniels (1936) regarded the anal intermuscular septum as the terminal part of the longitudinal muscle coat, in which situation it is largely fibrous and corresponds to the pecten band described by Abel.

Milligan (1942), in a further publication, enumerated four fibromuscular expansions that form the termination of the longitudinal coat. These are: (1) a septum passing to the ischiorectal fossa; (2) the intermuscular septum attached to the mucocutaneous junction, which may be stretched or absent in cases with third-degree piles; (3) the corrugator cutis ani muscle; and (4) the recto-urethralis muscle.

Eaton (1942) postulated the presence of an anal web in the chimpanzee and man. He suggested that the longitudinal muscle of the rectum binds together the circular rings of the sphincters and, reinforced by levator ani, secures firm anchorage to the pelvic brim. He considered the longitudinal coat formed sheath-like skirts that passed centrifugally through the external sphincter binding together its components. Whitney (1943) described two attachments for the longitudinal muscle: (1) the anal intermuscular septum; and (2) the skin at the anal verge.

The presence of involuntary muscle in the submucosa of the pecten was observed by Fine and Lawes (1940), and by Hill, Shryock, and ReBell (1943). The name 'musculus submucosæ ani' was proposed for these fibres by the former writers.

PRESENT INVESTIGATION

Method.—The adult material was absolutely fresh, being obtained from cases of perineo-abdominal resection of the rectum. After macroscopical study paraffin sections were cut in the sagittal and coronal planes on the sledge microtome. The sections were stained by three standard methods: (*a*) Hæmalum and eosin; (*b*) Van Gieson technique; (*c*) Weigert elastic tissue stain.

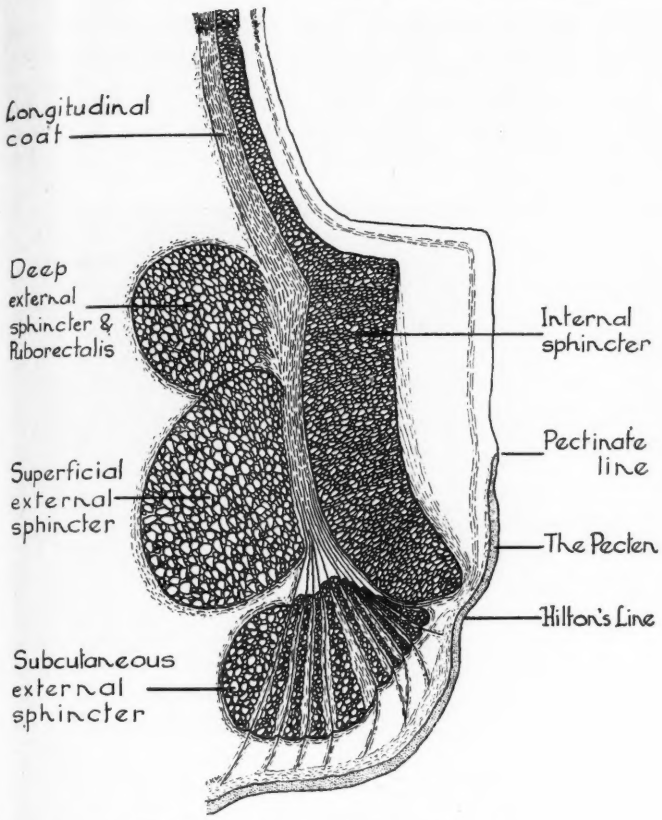

FIG. 396.—Diagram of longitudinal section through the anal canal.

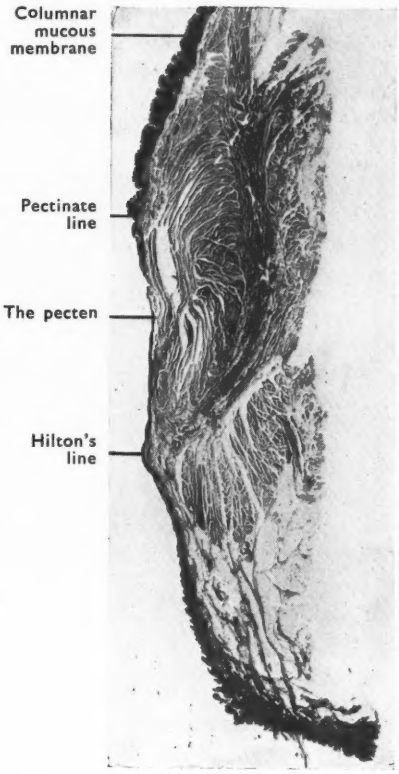

FIG. 397.—Adult anal canal. Longitudinal section.

As the patients were mainly elderly and all cases of frank carcinoma, three full-term fœtuses and five infants, 3–5 months of age, were examined by the same histological methods. Investigation of this additional material was considered essential, as the anal intermuscular septum has been described as being stretched or absent in cases with third-degree piles. Moreover the involuntary muscle in the submucosa of the anal canal is said to become hypertrophied with advancing age. The latter statement could not be corroborated, as the youngest adult specimen was from a patient aged 45 years, whilst in the newborn the muscle-fibres are still in the process of differentiation. Otherwise no differences were detected in the material of both groups.

Descriptions of Preparations.—

1. *General Disposition of the Sphincters and Mucous Membrane* (*Figs.* 396, 398, 401, 404, 405).—

The *internal sphincter* is a pronounced thickening of the circular muscle coat, measuring 30–35 mm. in length and 5–8 mm. in breadth, in the adult.

The *pectinate line*, marking the abrupt change from typical rectal mucous membrane to the stratified epithelium of the pecten, is situated opposite the middle of the internal sphincter. The pecten was described by Stroud (1896) as a zone of transition between the rectal mucous membrane above and the true skin below, being composed of simple stratified epithelium devoid of skin appendages and dermal papillæ. He stated that this area measured 3–9 mm. in breadth, being limited proximally by the pectinate line and distally by Hilton's line. The sections in

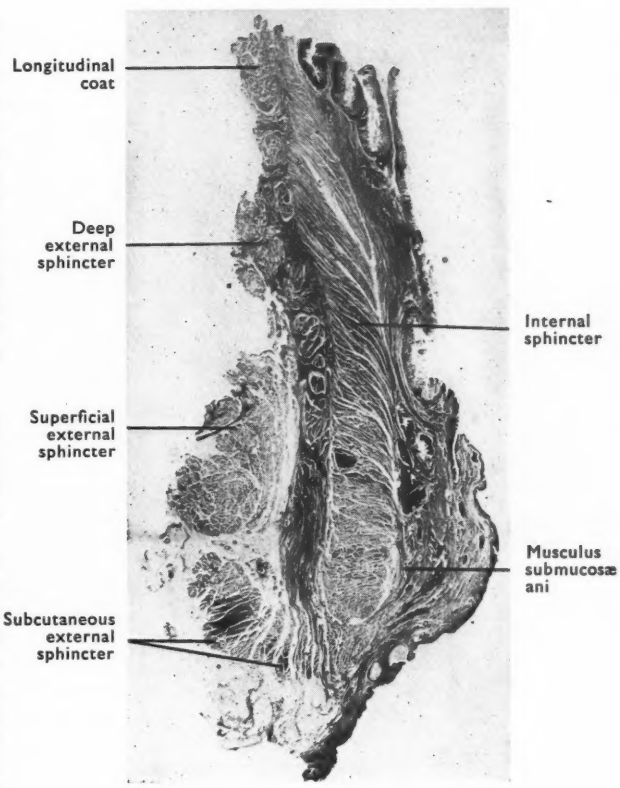

FIG. 398.—Adult anal canal. Longitudinal section.

this series, however, showed this region to be almost constant in breadth, measuring 15 mm. in the adult, and terminating below at the lower border of the internal sphincter; this coincides with Hilton's own description regarding the position of the white line (1892). Hilton's line is difficult to distinguish macroscopically in fresh specimens and this may account for the somewhat different positions ascribed to it by various writers.

The *external sphincter* may be subdivided into three parts, termed the subcutaneous, superficial, and deep external sphincters, respectively. The subcutaneous external sphincter is a flat band 15 mm. in breadth, and lies horizontally across the distal borders of the superficial external and the internal sphincters. Medially its fibres lie immediately beneath the skin at Hilton's line, virtually in contact with the inferior border of the internal sphincter. The superficial external sphincter lies deep to the subcutaneous component, from which it is demarcated by a fibro-elastic septum in the majority of specimens. The deep external sphincter is fused with, and indistinguishable from, the puborectalis fibres of the levator ani.

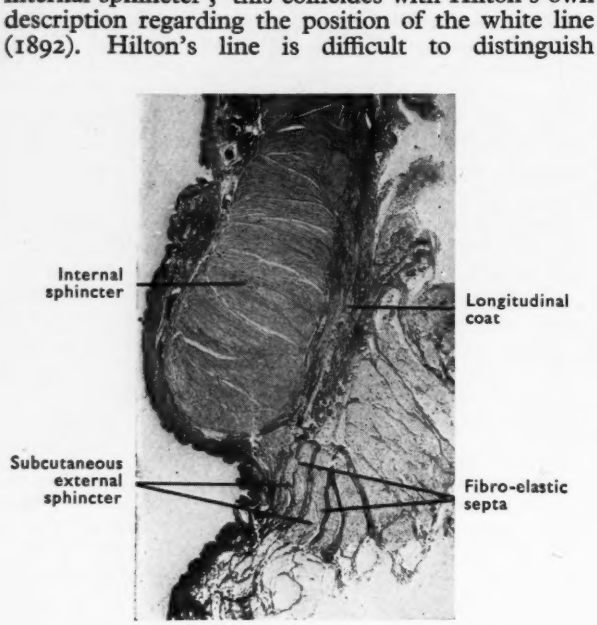

FIG. 399.—Adult anal canal. Longitudinal section.

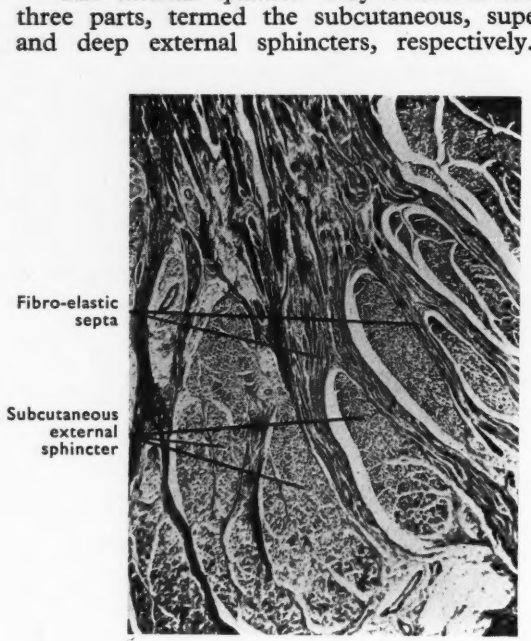

FIG. 400.—Photomicrograph of fibro-elastic septa. Infant.

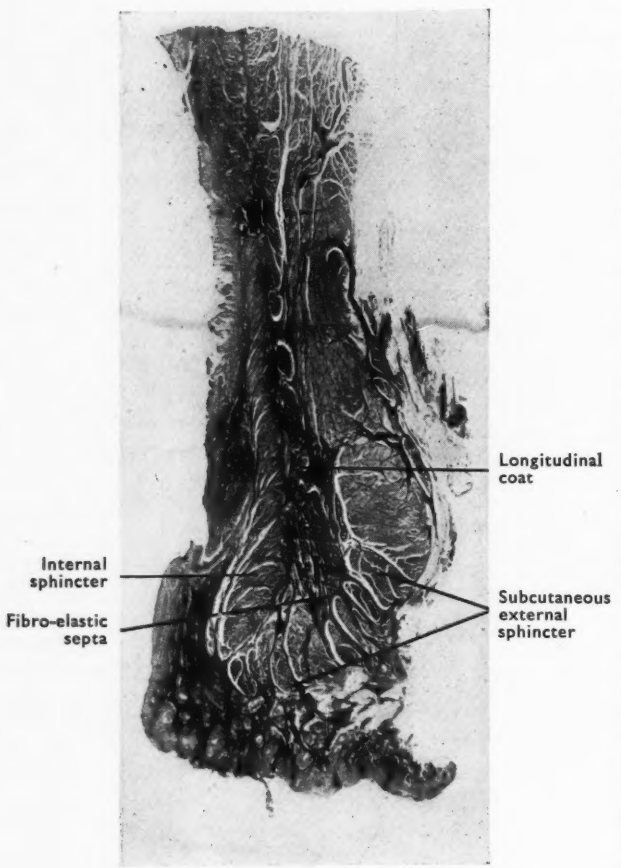

FIG. 401.—Anal canal (infant). Longitudinal section. Weigert elastic tissue and Van Gieson staining.

2. *The Longitudinal Fibres* (*Figs.* 397, 398, 401, 404, 405).—The involuntary longitudinal fibres of the hindgut fuse in the proximal part of the anal canal with those of the levator ani, forming a conjoint longitudinal coat. The levator fibres rapidly lose their identity in this structure, there being few voluntary fibres evident distal to the level of the pectinate line, and none beyond the inferior border of the superficial external sphincter. At this level, the longitudinal coat is composed of connective tissue, involuntary muscle, and many elastic fibres.

3. *The Attachment of the Longitudinal Muscle* (*Figs.* 398, 399, 400, 402, 403).—The conjoint longitudinal stratum breaks up on reaching the inferior border of the superficial external sphincter into a number of fibro-elastic septa. These, from 9 to 12 in number, spread out fanwise and pass through the subcutaneous external sphincter in a radiating manner. They are attached to the dermis of the true skin from Hilton's line to a point well beyond the anal verge (*Figs.* 399, 400).

The Van Gieson preparations confirm the fibromuscular composition of the longitudinal coat. The

proportions of muscle and fibrous tissue are about equal at the level of the lower border of the superficial external sphincter, and the radiating septa are almost entirely fibro-elastic, although isolated involuntary muscle-fibres are evident in these as far as their point of fusion with the dermis.

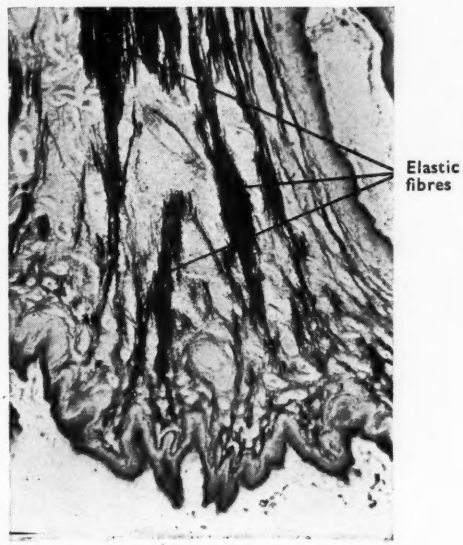

FIG. 402.—Photomicrograph. Showing fibro-elastic septa terminating in the perianal skin. Weigert elastic tissue stain.

4. *The Elastic Tissue.*—Special staining methods for elastic tissue show the presence of elastic fibres in the longitudinal layer where this is becoming fibrous at the level of the upper border of the superficial external sphincter (*Fig.* 401). Increasing rapidly in bulk relative to the muscle-fibres, this elastic tissue forms the chief moiety of the fibro-elastic septa that form the distal attachment of the longitudinal layer (*Figs.* 402, 403). Elastic fibres are also present in the levator ani at the point where this muscle fuses with the longitudinal coat; and in the septa that pass between the three components of the external sphincter. These may be seen ranging out laterally beyond the sphincter into the ischiorectal fossa (*Fig.* 404).

5. *The Musculus Submucosæ Ani.*—This name was used by Fine and Lawes (1940) to describe a layer of involuntary muscle-fibres in the submucosa of the pecten zone. The sections confirm the presence of such fibres. Proximally they are derived from two sources (*Fig.* 405):—

a. The more superficial, i.e., those nearer the lumen, are continuous with the muscularis mucosæ of the hindgut at the level of the pectinate line.

b. The deeper fibres are derived from the outer longitudinal muscle and may be traced between the bundles of the internal sphincter to reach the submucosa.

The two strata, superficial and deep, fuse (*Fig.* 405) as they are traced distally and become continuous with the most medial septum of the longitudinal coat by forming a loop around the inferior border of the internal sphincter.

The pecten zone is also rich in elastic fibres, which are concentrated into two strata—one being superficial and situated in the dermis of the pecten; the other deep and closely applied to the internal sphincter.

At the distal border of the internal sphincter the fibres of the superficial group continue into the dermis of the true skin, and the deep fibres join those in the medial fibro-elastic septum of the longitudinal coat.

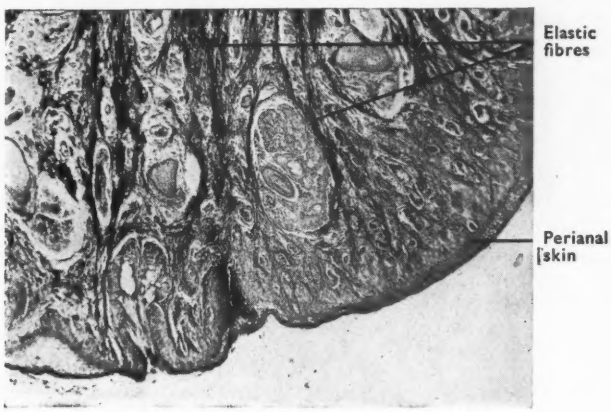

FIG. 403.—Photomicrograph showing termination of longitudinal fibres in the perianal skin. Weigert elastic tissue stain.

The structure of the submucosa of the pecten and that of the more proximal zone affords a striking contrast. The glandular mucous membrane of the hindgut is supported only by lax areolar tissue and

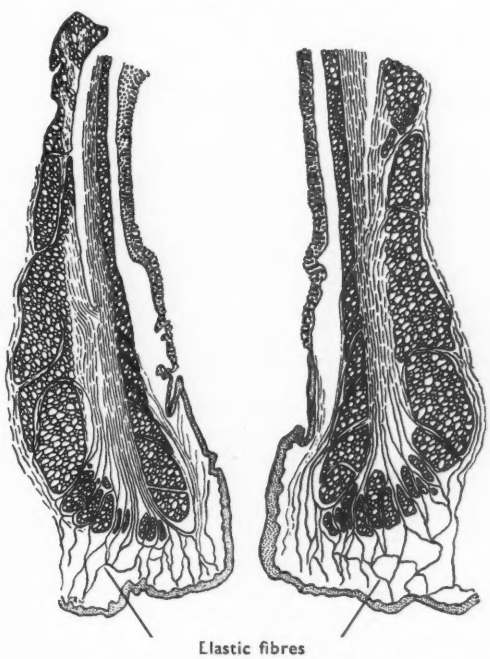

FIG. 404.—Diagram to show distribution of elastic fibres in the termination of the longitudinal aponeurosis.

a thin regular muscularis mucosæ. The comparatively dense connective-tissue matrix of the pecten zone, however, with its thick muscular and elastic components, suggests firm support and anchorage of the mucous membrane to its underlying bed.

Muscle-fibres are visible in the submucosa of the pecten in the newborn, but are not arranged in a regular manner nor do they constitute a definite layer. They retain Van Gieson's stain only feebly and appear to be still in the process of differentiation.

6. *The Corrugator Cutis Ani Muscle.*—The presence of involuntary fibres in the submucosa of the anal canal had been observed by many anatomists in the nineteenth century, notably Kohlrausch (1854)

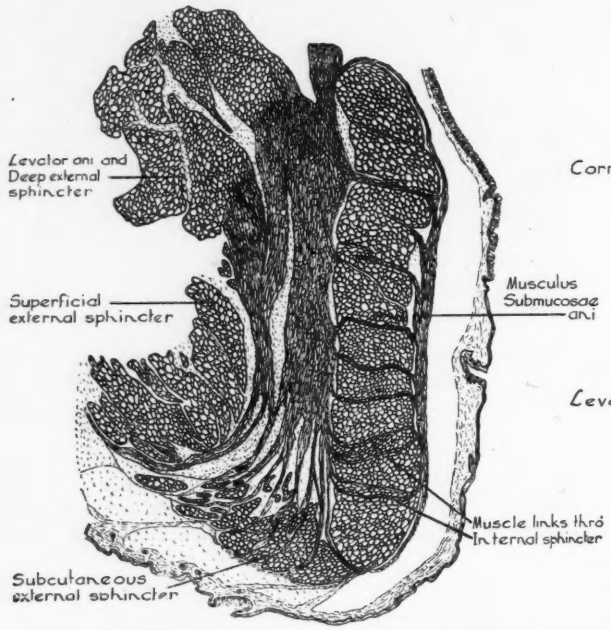

FIG. 405.—Diagram to show the position of the musculus submucosæ ani, and its connexion with the longitudinal muscle coat.

and Rudinger (1878). Béraud (1858) described the caudal attachment of the longitudinal coat of the anal canal in some detail. This he considered to take the form of a number of tendinous or aponeurotic cords that traversed the external sphincter and were attached to the skin of the anus in the depths of the radiating folds. The deepest of these encircled the lower border of the internal sphincter to reach the mucous membrane of the rectum. Béraud stated quite definitely that these longitudinal fibres, aponeurotic or tendinous in structure and attached to the anal skin, were responsible for the characteristic radiating folds of the anus.

The name 'corrugator cutis ani' was suggested by Ellis (1878) to describe a thin layer of involuntary fibres extending around the anus in the subcutaneous tissue. The muscle arose distal to the internal sphincter, and converging upon the anus terminated in the submucosa of the anal canal within the internal sphincter.

The corrugator cutis ani appears to have aroused little further interest until 1934, when J. W. Morgan described the muscle as involuntary, and as representing the lower medial edge of the longitudinal coat of the rectum. E. T. C. Milligan (1942) also described the muscle as a prolongation of the longitudinal muscle downwards in a radiating sheet. The muscle intervened between the subcutaneous external sphincter and the overlying skin of the anus and anal canal, gaining attachment to these skin coverings.

The original description (Ellis, 1878) suggests the presence of muscle-fibres radiating from the anus into the dermis of the surrounding skin (*Fig.* 406). This has been interpreted in various ways, but a recent article by E. T. C. Milligan (1942) shows the muscle as a flat subcutaneous sheet immediately beneath the perianal skin, and extending into the anus itself. There is no evidence of any such muscle in the present series of sections.

Dissection of the perianal skin in two full-term fœtuses (*Fig.* 407) revealed pale white strands in the

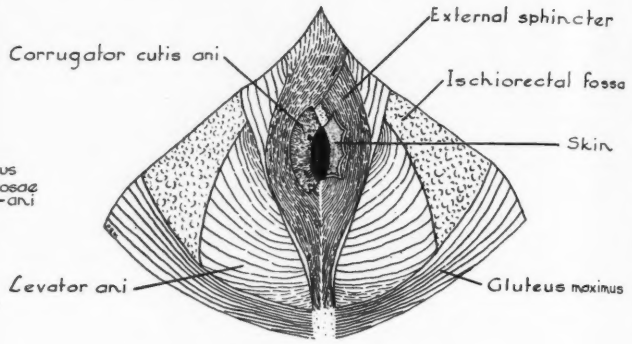

FIG. 406.—The corrugator cutis ani 'muscle'. (*After Ellis and Ford.*)

position described by Ellis. These were, however, merely the final ramifications of the conjoint longitudinal coat, and their fibro-elastic structure was confirmed by histological examination of the bundles.

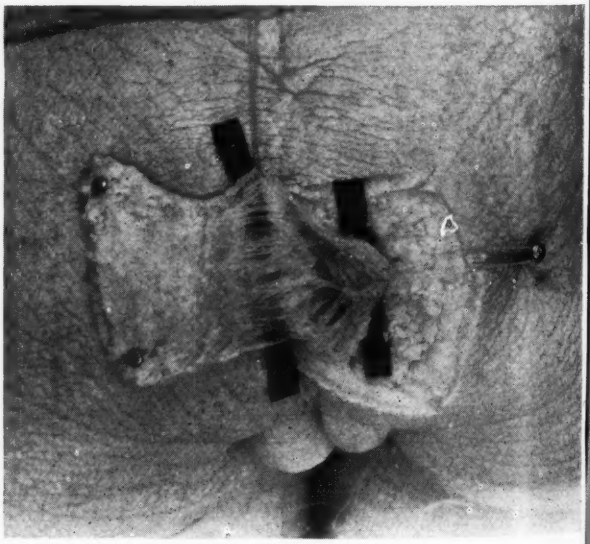

FIG. 407.—Dissection to show fibro-elastic septa (infant). These terminate in the perianal skin. The mucous membrane has been retracted to the left, and covers the lumen.

DISCUSSION

The concept of an anal intermuscular septum composed of almost the entire downward prolongation of the conjoint longitudinal muscle coat is

incorrect. An examination of the sections confirms the more classic description of a brush-like diffusion of the conjoint longitudinal fibres. These are attached in a radiating manner to the skin over a broad area from Hilton's line to a point well beyond the anal verge. The most medial of these septa does in fact pass between the subcutaneous external sphincter and the internal sphincter, but the remainder traverse the subcutaneous sphincter to reach a more peripheral attachment.

The presence of such radiating strands within the substance of the subcutaneous external sphincter would appear to afford a ready pathway for the track of a low-level anal fistula.

The highly elastic nature of the terminal septa of the conjoint longitudinal coat is responsible for the characteristic puckering of the anal skin. Such septa appear as pale round bundles when exposed by dissection and may readily be mistaken for involuntary muscle-fibres. Proximally they are continuous with the musculus submucosæ ani within the anal canal. Thus they correspond exactly in position and direction with the fibres described by Ellis as the corrugator cutis ani " muscle ".

The fibro-elastic septa are firmly attached to the dermis of the true skin. The compact ' honeycomb ' thus created in the narrow interval between the subcutaneous external sphincter and the perianal skin may account for the rapid rise of tension, with resulting pain, that attends the appearance of a perianal hæmatoma or thrombosed external pile.

CONCLUSIONS

1. The internal sphincter is a pronounced thickening of the circular muscle coat, measuring 30–35 mm. in length and 5–8 mm. in breadth, in the adult.

2. The pecten zone is an area of transition between the rectal mucous membrane and the true skin. This region has its own macroscopical and microscopical characteristics and measures 15 mm. in breadth in the adult.

3. The longitudinal muscle coat fuses at the level of the deep external sphincter with the adjacent fibres of levator ani. The conjoint aponeurosis so formed becomes increasingly fibro-elastic as it descends.

4. The conjoint aponeurosis divides distally into a number of fibro-elastic cords that fan out to gain attachment to the anal skin over a broad area extending proximally to Hilton's line, and distally beyond the anal verge.

5. There is no evidence of any special thickening or aponeurosis in the position usually ascribed to the anal intermuscular septum.

6. Corrugation of the anal skin is an expression in function of the radiating septate structure of the termination of the longitudinal coat. There is no evidence for the existence of a separate corrugator cutis ani muscle as described by Ellis (1878), and it is believed that the fibres he figured were in reality elastic in structure and radiating from the terminal septa of the longitudinal coat.

7. It is suggested that the manner of insertion of the conjoint longitudinal coat affords ready passage to the skin of a low-level anal fistula. Furthermore, the subdivision of the perianal subcutaneous tissue into a honeycomb by tough fibro-elastic septa may explain the localization and painful nature of a hæmatoma following rupture of a vessel in the external annulus hæmorrhoidalis.

My sincere thanks are due to Professor G. A. G. Mitchell, in whose Department the work was undertaken, and to whom I am indebted for much helpful advice; to Mr. P. G. McEvedy, from whom the adult material was obtained; and to Mr. Gooding and Mr. Pearson, of the Anatomical Research Laboratory, for the photography and preparation of the slides.

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INVESTIGATION AND TREATMENT OF ARTERIAL DISTURBANCES IN THE LOWER LIMBS

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THE investigation of patients complaining of intermittent claudication and peripheral vascular disease has been largely dependent on clinical tests and observations. While these tests are regarded as essential, it was felt that in the presence of so many variable factors which are difficult to control, the adoption of routine arteriography would give more positive evidence. For the last fifteen months this practice has been adopted in all such cases referred to us at this hospital.

Peripheral arteries were demonstrated for the first time radiologically over fifty years ago when Haschek and Lindenthal (1896) injected the vessels of an amputated limb with radio-opaque material. From then on this method was used extensively in many anatomy departments all over the world. To Berberich and Hirsch (1923) must go the credit for the first successful arteriogram carried out on the living. These authors used strontium bromide as a radiopaque substance, a medium which has now been superseded. With the development of safer and better opaque materials further progress was made, and many reports of successful arteriography appeared in the literature, the more important landmarks being Demel, Sgalitzer, and Kollert (1931, a, b), Dos Santos, Lomas, and Caldos (1931), Allen (1933, 1935). A complete review of the earlier work on the subject will be found in the paper by Edwards (1933). The advent of the diodone compounds opened a new chapter in the technique of peripheral arteriography, and within the past two years arteriography has become an everyday procedure in many clinics.

INDICATIONS

In the present series arteriography was carried out to demonstrate the presence, localization, and nature of pathological changes in the arterial tree of the lower limb, and the efficiency of the collateral circulation. Anteroposterior projections were used in all cases. When the symptoms were bilateral, both legs were injected. Lateral projections were also taken in all patients suffering from thrombo-angiitis obliterans, and also in those with degenerative conditions of the arteries, if the circulation was reasonably good.

The speed with which reactive hyperæmia, produced by the first injection of contrast medium, spread from the site of injection to the foot was accepted as a satisfactory criterion of an efficient circulation. It has been found by experience that if the leg is flushed within 20 seconds after the injection lateral examination is safe. If, however, the hyperæmia is blotchy, producing a map-like appearance of the skin, the blood-supply was considered to be inadequate and lateral projection unsafe.

It was found that in limbs with poor blood-supply there were either extensive contour changes present throughout the arterial system, or thrombosis in the distal two-thirds of the femoral artery. In cases with adequate circulation or when a clinical diagnosis of thrombo-angiitis obliterans was made, pathological changes were more peripherally placed, i.e., in the distal third of the femoral artery, the popliteal, or the anterior and posterior tibial arteries and their branches. It is in the latter group of cases that lateral projection is often helpful in demonstrating the lesion or the localization of thrombosis or arterial narrowing which is not visible in the anteroposterior projections. As much as 40 c.c. of contrast medium have been injected rapidly into the femoral artery, followed by anteroposterior and lateral radiographs, without untoward effects.

TECHNIQUE OF ARTERIOGRAPHY

The patient lies supine on a shallow, flat cassette tunnel with open sides, placed on the operating table. The tunnel is constructed in such a way that standard X-ray cassettes can be slipped in and out freely under the entire length of the lower limb in any position from hip to ankle. In this way anteroposterior radiographs can be taken quite simply without moving the leg during the examination. A central groove in the upper surface of the cassette tunnel will hold X-ray cassettes in the vertical position between the patient's legs for lateral radiography (*Fig.* 408). Six X-ray cassettes, 15 in. by 6 in.,

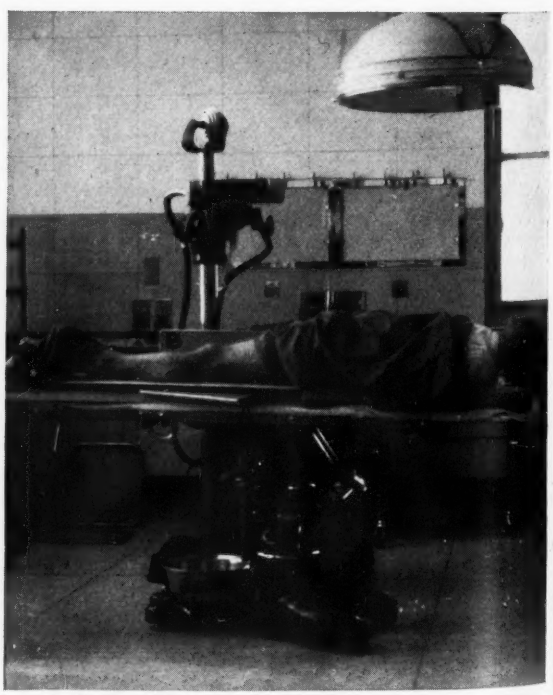

FIG. 408.—Patient lying on cassette tunnel. A, Cassette in position for the anteroposterior examination; B, Cassette in position for lateral examination.

are used for each examination; this number covers the entire limb adequately from the level of the hip-joint down to the ankle and so the entire arterial tree, excluding the foot, can be demonstrated.

A mobile X-ray unit has been used with the following radiographic factors: 60 K.V.P., 60 ma., and an exposure of 0·2-0·4 seconds was given, according to the thickness of the limb; the tube distance was approximately 36 in. Pyelosil 50 per cent was used as radiopaque material, 20 c.c. being injected rapidly into the femoral artery. This amount was found by experience to give good radiographs of the vessels. This substance is non-toxic and has produced no serious after-effects. Many patients complain of intense pain in the calf when the medium is injected rapidly under local anæsthesia. Therefore, it was decided to use a general anæsthetic.

Perabrodil 50 per cent has been used by Learmonth (1944), who found 10 c.c. sufficient. The examinations were carried out under spinal anæsthesia, and no dangerous after-effects were noted. Thorotrast has not been used in our series, and its use seems contra-indicated, since it is not without dangerous after-effects (Taft, 1937). It should be mentioned that others (Allen and Camp, 1935; Yates and Coe, 1943) claim it to be quite harmless in small quantities, although Camp and his co-workers now use a diodone compound in 50 per cent concentration. Iodosol (ethyl-tri-iodostearate), a radiopaque substance developed by Degkwitz in 1938, was used extensively in Germany before the war for arteriography.

The operative technique is simple. Percutaneous methods have not been employed, as the exact position of the needle, whether in the common or superficial femoral, could not be determined. It has been found that the femoral artery often divides immediately under Poupart's ligament, and in the obese individual it is virtually impossible to get above the origin of the profunda femoris by the percutaneous route. A vertical incision is made 1½ in. in length over the femoral artery, the upper end of the incision extending over Poupart's ligament, and the artery exposed. A thin rubber sling is passed around the artery and the two free ends are clipped. By this means an assistant, by applying tension, occludes the vessel. The common femoral, superficial femoral, and profunda femoris are then identified. When this has been done and everything is ready for injection, the radiographic staff takes over.

Technical Details.—To obtain smooth and speedy working which is so essential to the success of this examination, three radiographers are employed. 'Number 1' places the X-ray cassettes and removes the exposed ones. 'Number 2' is in charge of the mobile unit and 'centring' of the X-ray tube. 'Number 3' feeds unexposed cassettes to 'Number 1' and retrieves the exposed ones. After the common femoral artery has been exposed and before the injection is started, the instruments are removed. The foot being held by a nurse in full internal rotation, the first cassette is placed high up under the thigh to visualize the deep and superficial branches of the femoral artery. The assistant then occludes the common femoral artery by exerting tension on the rubber sling and a short, sharp,

Table I.—Cases of Arteriosclerosis

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Age	62	63	61	65	67	65	60	47	59	40	56	52	58	62	65	65	50	53	68	65	62	65	66	71	47	52
Sex	M.	F.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.
Side (right or left)	R.	R., L.	R.	L.	L.	L.	R.	R., L.	R.	R., L.	L.	R., L.	R.	R., L.	L.	L.	L.	R.	R.	L.	R., L.	R.	R.	L.	R., L.	R., L.
Atheroma	+	+ +	+	+	+	+	+	+ +	+	+ +	+	+ +	+	+ +	+	+	+	+	+	+	+ +	+	+	+	+ +	+ +
Thrombosis	+	+ +	+	+	+	+	+	+ +	+	+ +	+	+ +	+	+ +	+	+	+	+	+	+	+ +	+	o	o	+ +	o
Deep femoral	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+ o	o
Superficial femoral*	F_2	F_2, F_3, 3	F_3	F_3	o	F_3	F_1	F_2, F_3	F_3	F_1, F_3	F_3	F_2, F_3	F_2	$F_{1,2}$, $F_{1,2}$	o	F_3	F_3	F_3	o	F_3	F_2, F_2	F_2, 3	o	o	F_2, F_3	o
Popliteal	o	o	+	o	+	o	o	o	+	o +	o	o	o	o	+	o	o	o	o	o	o	o	o	o	o	o
Anterior tibial	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Posterior tibial	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	+	o	o	o	o	o	o	o
Collaterals	+	+	+	+	+	+	o	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	?	o	+	+
Venous filling	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o

Site of thrombosis

*F_1 Proximal third; F_2 Middle third; F_3 Distal third.

bevelled needle of at least 1 mm. diameter is inserted into the lumen of the vessel. After 10 c.c. has been injected the first exposure is made, the exposed cassette being rapidly replaced by a fresh one, which is moved farther down the leg, the X-ray tube is re-centred, and the second exposure made. Six cassettes are necessary to visualize the vessels of the lower limb. A considerable overlap of the areas visualized is necessary to get a complete picture. The whole radiographic procedure should be finished in 20 seconds. The injection should be completed in 5 seconds, which time coincides with the third exposure, but the sling around the artery is not released by the assistant until after the fifth exposure, by which time the arteries below the knee are being visualized.

With good teamwork, provision of all necessary facilities, and co-operation between surgical and radiographic staffs, the examination has been found to present few technical difficulties, in either antero-posterior or lateral planes.

Certain small but irritating accidents have occurred :—

1. Atheromatous areas should be avoided owing to the possibility of breaking off an atheromatous plaque or piece of vessel wall, with subsequent blocking of the vessel or a small leakage.

2. Care should be given to the point of the needle, as, if it is ' turned over ', a small triangular piece of artery may be torn out, with the consequent risk of hæmorrhage.

3. Small un-named branches have been damaged in manipulation. These can be easily picked up and tied. Otherwise bleeding has been easily and completely controlled by pressure for two or three minutes.

4. A blotchy appearance of the skin is seen within a few seconds of completion of the injection, which in cases of extensive arterial disease may persist for several hours. If the arterial disease is localized this appearance passes off in fifteen to thirty minutes. Older ' arteriosclerotic ' patients state that their feet become warm for several days, night cramps being relieved during the same period.

We have had no dangerous complication resulting from arteriography, even when the superficial femoral has been thrombosed in its whole length.

THE CLINICAL CASES

Arteriography was carried out in 46 patients. In 26 a diagnosis of arteriosclerosis was made; of these 25 were males and only 1 female. Their ages ranged from 40 to 71. In 8 of these bilateral arteriography was carried out, the right limb only was examined in 9, and the left in the remainder. (*Table I.*)

Atheromatous changes were present to a varying degree, the superficial femoral artery being involved in all cases. In 30 limbs thrombosis of a main artery was present. This affected the proximal third of the superficial femoral in 4, the middle third in 19, and the distal third in 7 limbs. The profunda branch was affected in only 1 case. In this series thrombosis occurs most commonly in the middle third of the superficial femoral. The popliteal artery was thrombosed in 5 limbs, and the posterior tibial in 1; the anterior tibial, strange to say, was never occluded. Collateral vessels were delineated in all but two limbs, and one of these is doubtful. Venous filling was only seen in 1 limb.

Table II.—Cases of Thrombo-angitis Obliterans

Number		1	2	3	4	5	6	7	8	9	10	11
Age		57	60	60	45	26	42	34	45	38	53	45
Sex		M.	M.	M.	M.	M.	M.	M.	M.	M.	M.	M.
Side (right or left)		L.	R., L.	R., L.	R., L.	L.	L.	R.	R.	R.	R.	L.
Contour changes		+	++	++	o	o	o	o	o	+	o	+
Thrombosis		+	++	o	++	+	+	+	+	o	+	o
Site of Thrombosis	Deep femoral	o	o	o	o	o	o	o	o	o	o	o
	Superficial femoral*	$F_{2,3}$	o	o	o	F_3	$F_{2,3}$	F_3	$F_{2,3}$	o	$F_{2,3}$	o
	Popliteal	+	o	o	o	o	+	+	o	o	o	o
	Anterior tibial	o	o+	o	++	o	o	o	o	o	o	o
	Posterior tibial	o	++	o	++	o	o	o	o	o	o	o
Collaterals		+	+	+	+	+	+	+	+	?	+	+
Venous filling		o	o	o	o	o	o	o	+	o	o	o

* F_1 Proximal third; F_2 Middle third; F_3 Distal third.

In 11 patients a diagnosis of thrombo-angiitis obliterans was made; they were all males and their ages ranged from 26 years to 60 years. In 3 cases both limbs were affected, the right leg only in 4, and the left in a similar number. Changes of arterial contour were present in 7 limbs, the distal third of the superficial femoral and the proximal popliteal being affected. There was smooth persistent narrowing of the affected segment of the artery, and in one limb the artery was not only narrowed but kinked.

In 10 limbs arterial thrombosis was also present. In 4 of these the middle third of the superficial femoral was involved, and in 6 the distal third. The proximal third of the superficial femoral artery or the profunda femoris was not affected in any case. The popliteal artery was thrombosed in 3, the anterior tibial in 3, and the posterior tibial in 4 cases. A good collateral pathway was outlined in all but one limb. Venous filling was seen only once. (*Table II.*)

In spite of the symptoms 9 patients had normal arteriograms. Of these 1 had a bilateral examination, 7 had the right limb and 3 the left examined. Their ages varied from 16 years to 48 years; seven were males and two females. Five patients complained of previous recurrent thrombophlebitis, 1 of a varicose ulcer, 1 of a trophic ulcer, 1 had a Volkmann's ischæmic contracture of the calf muscles, and 1 impaired circulation in the leg following trauma, due to laceration of the popliteal artery (*Table III*).

Table III.—NORMAL ARTERIOGRAMS

NUMBER	1	2	3	4	5	6	7	8	9
Age	24	42	45	31	33	25	20	16	48
Sex	M.	M.	M.	M.	F.	M.	M.	M.	F.
Side (right or left)	R.	R.	L.	R., L.	R.	R.	L.	R.	R.
Venous filling	0	+	?	++	+	+	+	+	+

RADIOLOGICAL DISCUSSION

Following Allen and Camp's work (1935) on peripheral arteriography, the following points have to be observed in assessing the radiological appearances :—

1. Variations in the normal anatomy.
2. Alterations in lumen or contour, suggesting thrombosis.
3. The delineation of collaterals. Collaterals will not be delineated : (*a*) when main vessels are adequate, (*b*) when they or their appropriate segments of the parent vessels are affected.
4. Evidence of venous filling after arterial injection.

In the normal arteriogram of the lower limb only the larger arteries are visualized well with contrast media. Venous filling is usually seen on the third or fourth films ; it only occurred once in the present series in any pathological arteriogram (*Fig.* 409). The contour of the vessels is normally perfectly smooth, and their calibre constant for a considerable length of their course, which is straight. There is very little visible filling of smaller arteries or collaterals. Occasionally an artery will appear uniformly narrowed for a short distance, but the width of the lumen above and below the narrowed portion appears normal. The narrowing is probably due to spasm induced either by arterial puncture, in which case the spasm will appear at the site of puncture, or by too rapid injection producing irritation of the intima. Arterial spasm may relax during the examination, in which case the narrowed portion of the artery will appear to have a different calibre on the successive radiographs. The narrowing due to arterial spasm must be differentiated from true pathological narrowing, which is constant throughout the serial radiographs. and is asymmetrical, occasionally irregular, and accompanied by collateral channels.

The changes seen in peripheral vascular disease on arteriograms are numerous and varied :—

Arteriosclerosis.—

1. Normal radiographs of the limb not infrequently show calcification of the media. The arteriograms show the lesions as widespread and affecting several of the larger vessels. The arterial contour is irregular in the diseased areas (*Fig.* 410).

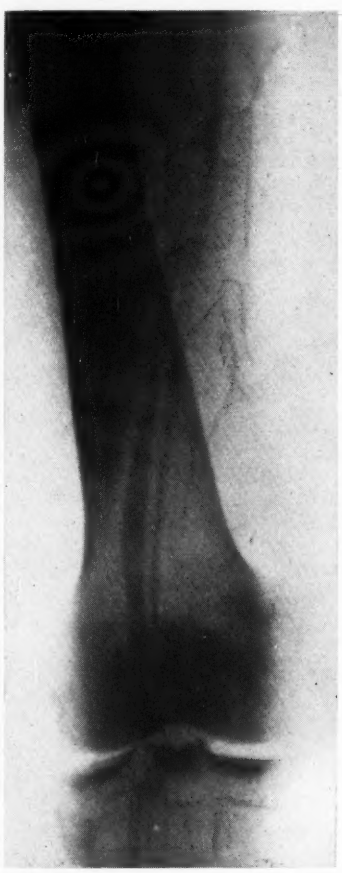

FIG. 409.—The femoral artery and vein are demonstrated side by side.

FIG. 410.—Extensive atheromatous changes are demonstrated in the superficial femoral artery. The middle third of the superficial femoral is thrombosed.

FIG. 411.—Thrombosis of the middle third of the femoral artery.

FIG. 412.—Thrombosis of the lower third of the superficial femoral artery; extensive collaterals are shown.

Fig. 413.—Three cases, showing a bulbous dilatation of the artery at the site of thrombosis and re-entry of collaterals at right angles.

In the later stages the arterial wall has a shaggy outline and the lumen becomes narrowed.

2. The next stage is vascular occlusion, which usually affects a large main artery; rarely a small peripheral vessel may also be involved (*Figs.* 410, 411). The thrombosis may be very extensive and show clear-cut ends. Collateral channels with a very inconstant distribution appear at an early stage in the disease; they can be clearly recognized by their tortuosity, large number, and calibre, which is narrower than that of the main arteries (*Figs.* 410-412). When thrombosis is present, the collateral vessels are seen to originate from the main arteries just above the site of thrombosis. Occasionally they are seen to originate at right angles from the main artery, but rapidly change their course and proceed parallel to the main vessel, finally re-entering it at right angles distal to the thrombus. At the point of origin and termination of the collateral vessels a localized bulbous dilatation is sometimes seen. This suggests that there is still some elastic tissue or muscle left in the vessel wall which responds to local pressure changes (*Fig.* 413). Occasionally the thrombus is canalized, and a narrow winding channel can be seen running through it. In one case only half the lumen of the middle third of the superficial femoral was occluded, a good channel remaining; this state of affairs extended for a considerable length along the femoral artery before complete occlusion occurred (*Fig.* 414).

The impression gained in the present series of cases is that collateral channels in peripheral arteriosclerosis are not so numerous as in thrombo-angiitis. Other factors influencing the number of collaterals are the age of the patient and the extent of atheromatous changes in the large and small arteries. Venous filling has not been seen, which suggests that the circulation time is increasing. The site of thrombosis varies considerably, but in the case of the superficial femoral artery it was found in the present series that in a large percentage of cases the distal half of the artery was thrombosed. Thrombosis of the popliteal artery was seen a few times, but tibial thrombosis or deep femoral thrombosis was exceedingly rare.

Thrombo-angiitis Obliterans.—Normal radiographs of the limb show no vascular calcification. In the present series of arteriograms only the larger arteries of the lower limb were visualized, so pathological changes affecting these vessels only can be described. In the early stages a smooth narrowing of the vascular lumen is noted, short in extent, localized in our series to the lower third of the femoral or to the popliteal arteries. In one case the narrowing was irregular and the artery appeared kinked (*Fig.* 415) and remained constant throughout the examination. It is difficult to differentiate between pathological narrowing and that due to spasm, but the criteria referred to above were found reliable. Collateral channels appear early, become numerous, and must, as shown by the absence of pain, give an adequate blood-supply to the resting limb. Contour changes in the arterial wall are localized and less widespread then in arteriosclerosis. In the more advanced case vascular occlusion is demonstrable, affecting either a large vessel or one or two smaller ones (*Figs.* 416, 417). The thrombosis

A B

FIG. 414.—A, Hemithrombosis of the middle third of the superficial femoral artery; B, Complete thrombosis of the distal third of the femoral artery.

ends sharply, and seems to cut across the lumen at right angles, or to show a smooth convex border (*Fig.* 418), and is not irregular as in some of the arteriosclerotic cases. A bulbous dilatation of the vessel just above and below the thrombosis may be seen, similar to that described above in the arteriosclerotic cases.

As with arteriosclerosis, thrombosis usually occurs in the distal half of the superficial femoral or popliteal artery. This striking selectivity must have some significance. The explanation probably depends upon unknown anatomical factors. Venous filling, a further indication of an impaired circulation, is not seen where any obvious arterial changes are present.

TREATMENT

Treatment has been based on two premises. First, the need for the production of vasodilatation in the peripheral vascular tree, and, secondly, the removal if possible of an irritant focus in the vessel. These objectives have been attempted by two methods: a course of paravertebral sympathetic blocks in the very old patients and, in the better risk patients, a lumbar sympathectomy with or without arteriectomy. Unilateral sympathectomy and arteriectomy have often been performed on the same side at one operation, and the other side completed, if necessary, some three weeks later.

FIG. 415.—A,B, Narrowing of the distal third of the superficial femoral artery; C, Narrowing with kinking of the distal third of the superficial femoral artery.

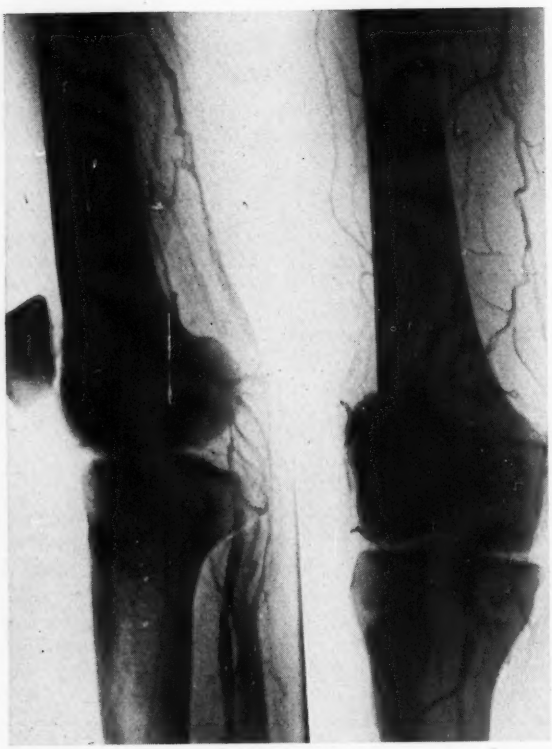

FIG. 416.—Thrombosis of the distal third of the superficial femoral artery and popliteal artery with extensive collateral circulation.

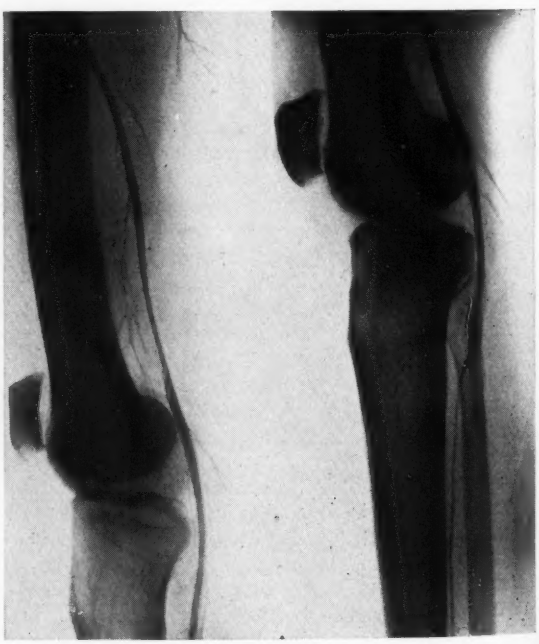

FIG. 417.—Narrowing of the distal third of the superficial femoral artery. Thrombosis of the posterior tibial artery, narrowing and kinking of the anterior tibial artery.

There has been one fatality due to pulmonary embolus on the eleventh day, in a male patient aged 65.

Certain observations have been made during the experience of this operation, which may account for some of the so-called failures of response to sympathectomy. First it is essential to obtain adequate exposure, particularly on the right side, and to localize the fourth lumbar ganglion where

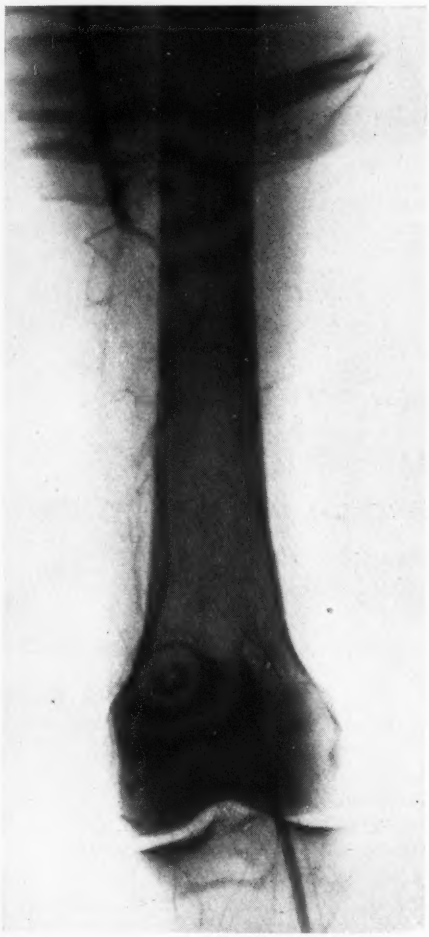

FIG. 418.—Extensive thrombosis of the superficial femoral artery. The artery is patent for a short distance in its middle third.

it lies immediately deep to the common iliac artery. The retroperitoneal approach through an incision extending from the tip of the tenth rib to an inch below the umbilicus has been used. It has been found that on very few occasions only has the lumbar sympathetic cord resembled its portrayal in anatomy books and that three or even four strands may represent the sympathetic outflow. In addition, extra branches and filaments may be found passing down from the sympathetic trunk above the line of section to the vessels and thence into the pelvis. It has been the practice after removal of obvious strands and ganglia from below the fourth ganglion up to the second, to denude as far as possible the anterior surfaces of the third and fourth lumbar vertebræ on that side, by removing all connective and lymphatic tissue. On the right side this is more difficult, owing to the presence of the inferior vena cava. By adopting this added precaution vasodilatation has been procured in all cases.

It has been found in the younger age groups where there is a localized thrombosis, that the vein and artery are intimately adherent, and great care must be exercised in separating them. The vein has been patent, however, despite its seeming involvement in the inflammatory process affecting the artery. This inflammatory process frequently involves the saphenous nerve, which may be firmly adherent and require the most careful dissection, and even then paræsthesia and numbness below the knee may be present for some weeks after operation. It has been found possible, with blunt dissection, to avoid a division of the tendinous arch in the adductor magnus.

It is of interest that the femoral thrombosis in the younger age groups has been at the opening in the adductor magnus. In this area the fascia lining the arch blends with the adventitia of the artery. It is suggested that the thrombosis occurring at this site is due to the pull of a muscle causing ' kinking ' at this point and so inducing a disturbance which slows the blood-stream. This would be particularly marked in hyperextension and powerful flexion. The kink would therefore be more frequent and marked in the younger patient than in the elderly. It will, of course, be recalled that this is a common site for luetic aneurysm and also for the ' postillion ' aneurysm of John Hunter's generation. The arteriogram is invaluable for demonstrating the precise extent of the thrombus and so avoiding unnecessary dissection for the arteriectomy.

A mild form of paralytic ileus and hiccup which may persist for two or three days seem to be a frequent post-operative complication of lumbar ganglionectomy.

RESULTS

It is too early to give a detailed analysis of our results, as sufficient time has not yet elapsed since the operations. A brief discussion, however, may be helpful. In the younger age groups with thrombosis of the lower third of the femoral artery, the results of treatment have been good. Normal range of walking cannot be anticipated except in a very few, but a useful range of 500-800 yd. is usual, as opposed to the 50-200 yd. prior to operation. Some cases return to complete activity, e.g., one patient can now play three sets of tennis, but as a rule a very guarded prognosis is advisable. There is complete relief of night cramps, and of the cold moist foot.

In the older patients results have been arbitrarily divided into three main groups. Approximately one-third have been greatly improved, a third are relieved of the cramps and cold feet but range of walking is only slightly improved, while the third group, although much more comfortable at rest, are little if at all improved in locomotion.

The younger age groups were treated by a lumbar sympathectomy and arteriectomy. This was done usually in one stage. In the older age groups it is better to deal with the problem in three separate stages. Initially, a course of Buerger's exercises is given. These, in our experience, have in a few

isolated cases produced a marked improvement, and further treatment has not been necessary. If there is no response after two months of exercises it has been our practice to give a course of six paravertebral blocks at intervals of three days. This course sometimes gives rise to great improvement. Finally, if the above efforts fail, surgery on the lines indicated has been adopted.

SUMMARY

1. A brief survey of the history of peripheral arteriography is given.

2. A technique for arteriography of the lower limbs is described.

3. The radiological features of peripheral vascular disease of the lower limbs are described and discussed.

4. The treatment and preliminary survey of the results are given.

Our gratitude is due to our colleagues for their co-operation in referring their patients for investigation; to Dr. J. L. A. Grout, Dr. J. Wilkie, and Dr. T. Lodge for their kindly criticism; and to Mr. W. H. J. Coombs, whose technical skill made the radiological investigation possible.

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INJECTION TREATMENT OF VARICOSE VEINS

RADIOLOGICAL AND HISTOLOGICAL INVESTIGATIONS OF METHODS

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INJECTIONS of sclerosing fluid, either alone or in conjunction with operation, play a large part in the modern treatment of varicose veins. In the past they have been used blindly and almost empirically. The investigations described here were undertaken to learn something of the fate of the injected fluid and its effect upon the different components of the venous tree.

These observations, which were started in 1946 in a R.A.F. Hospital, were completed at St. Bartholomew's Hospital, and were made on patients with primary varicose veins. All cases of compensatory veins, or any in which the past history suggested an attack of deep venous thrombosis, were excluded.

The radiological investigations which were undertaken first indicated that the methods of injection in common use might possibly damage valves and intima in deep, communicating, or even normal superficial veins, without permanently obliterating them. The histological studies were therefore undertaken to investigate the effect of doses of sclerosing agent which are too small to cause permanent obliteration.

Before dealing in detail with these sources of information it is necessary to consider the theoretical basis of the various therapeutic injection techniques.

THEORETICAL CONSIDERATIONS

In every therapeutic injection a solution which is damaging to living tissues is injected in order to obliterate the diseased vein. Inefficient channels containing stagnant or distal-flowing blood are thus eliminated.

Methods fall into two groups, according to whether the injected solution is fixed where it is injected or passes on to be diluted in the general circulation.

First Method: Immediate Clotting and Fixation.—In this method the injection is made into stationary blood behind a tourniquet. Blood and injected solution together form a clot which obliterates the channel concerned. It is thus hoped that the injected solution does not pass into the general circulation. Lord Lister used this technique, injecting pure carbolic acid and waiting until firm clotting had occurred before removing the tourniquet.

The chief objections to the method are: (1) The clot which results is painful and bulky; (2) The tourniquet stops the blood-flow in both superficial and deep veins. There is nothing to prevent the fluid when injected from running on into the deep channels and causing thrombosis in the stationary blood.

Embolism or other complications are liable to follow.

Lord Lister soon abandoned the method for these reasons, but there are still injection techniques in modern use founded on this principle.

Second Method: Delayed Clotting.—Most modern injection techniques employ this principle.

Fluid is injected into a vein, injures the lining, and then passes on into the general circulation,

where it is diluted. The damaged vein ultimately becomes filled with clot, which in time organizes. Obliteration will be permanent if sufficient injury has been done to the vein ; if not, recanalization will take place.

It is difficult to believe that any vein which recanalizes in this way with valves, intima, and walls damaged can be anything but less efficient than before the injection. Obviously the best injection is one that remains long enough to produce irretrievable damage to the diseased veins, and then passes on, to be diluted as quickly as possible.

Having dealt with these theoretical considerations let us see what light the venographic and histological studies throw upon current practice.

through a catheter passed from an incision in the groin.

The patients concerned had been selected for the operation of ligature of the great saphenous vein at its junction with the femoral vein because of incompetency of the valves in the great saphenous system demonstrated by clinical methods such as the Trendelenburg test, a thrill felt in the vein at the knee on coughing, or other tests.

Table I shows the results of a series of 17 venograms made by injecting amounts of dye varying from 2 to 7 c.c. down the great saphenous vein. It was found that appreciable amounts passed at once into communicating or deep veins, or into normal veins in the thigh. This has been expressed

Table I.—Showing Distribution of Dye injected down the Great Saphenous Vein in 17 Cases
(Estimated from venograms taken at time of completion of each injection)

Total Amount of Dye injected	Percentage Distribution of Dye						Result
	Great Saphenous Vein	Thigh or Calf Varices	Total in Target	Communicating or Deep Veins	Other Veins	Total off Target	
4 c.c.	—	90	90	—	10	10	Satisfactory
4 c.c.	20	20	40	50	10	60	Unsatisfactory
3 c.c.	—	100	100	—	—	—	Satisfactory
7 c.c.	20	40	60	30	10	40	Unsatisfactory
3 c.c.	90	—	90	10	—	10	Satisfactory
7 c.c.	50	—	50	50	—	50	Unsatisfactory
3 c.c.	5	—	5	—	95	95	Unsatisfactory
7 c.c.	50	—	50	—	50	50	Unsatisfactory
4 c.c.	50	—	50	50	—	50	Unsatisfactory
4 c.c.	50	—	50	50	—	50	Unsatisfactory
4 c.c.	20	40	60	40	—	40	Unsatisfactory
4 c.c.	30	—	30	70	—	70	Unsatisfactory
4 c.c.	—	—	—	90	10	100	Unsatisfactory
4 c.c.	10	—	10	40	50	90	Unsatisfactory
2 c.c.	50	—	50	—	50	50	Unsatisfactory
4 c.c.	40	—	40	10	50	60	Unsatisfactory
2 c.c.	40	—	40	60	—	60	Unsatisfactory
2 c.c.	60	—	60	40	—	40	Unsatisfactory
2 c.c.	90	—	90	—	10	10	Satisfactory
2 c.c.	10	80	90	—	10	10	Satisfactory

More than 40 per cent of the dye off the target was regarded as unsatisfactory.
Only 5 injections could be considered of satisfactory accuracy.

VENOGRAPHY

Injections imitating therapeutic procedures were made with urographic dyes. Diodone was chiefly used as this resembles 'Ethamoline' in that no immediate pain is caused on injection. Attempts to produce a radio-opaque sclerosant solution were unsuccessful, as all ordinary radio-opaque dyes were found to be incompatible with the sclerosants in common use.

Observations of three types were made :—

1. At operation : radiographs of retrograde injections down the great saphenous veins of patients selected for high ligature.

2. Fluoroscopic screening of injections of normal and varicose veins.

3. Serial venograms of direct injections of varicose veins.

1. Retrograde Injection at Operation.—The rationale of this type of injection is to obliterate the great saphenous vein, and if possible calf varicosities also, by injecting sclerosing fluid downwards, usually on a percentage basis estimated from venograms taken at the moment of completing the injection. The figures are, of course, only approximate, but the method avoids the alternative of reproducing all the venograms, which space would not allow. An injection in which 40 per cent or more of the dye passed at once out of the 'target area' (great saphenous vein and varicosities in thigh or calf) was considered unsatisfactory. On this basis only five injections out of seventeen could be considered of satisfactory accuracy.

Most of these injections were made through a ureteric catheter passed down to knee level. Variations in technique such as withdrawal of the catheter while injecting, or retrograde injection using a needle instead of the catheter, made no appreciable difference to the result. *Figs.* 419–421 are examples of unsatisfactory retrograde injections.

A second series of injections using larger amounts of dye (8–16 c.c.) merely resulted in a still larger amount passing at once out of the 'target' area of veins.

FIG. 419.—Retrograde injection of 4 c.c. of fluid. The catheter can be seen in the great saphenous vein, which contains no fluid : the dye has passed chiefly into the deep veins.

FIG. 420.—3 c.c. of dye injected while slowly withdrawing catheter. 50 per cent has passed into deep or communicating veins.

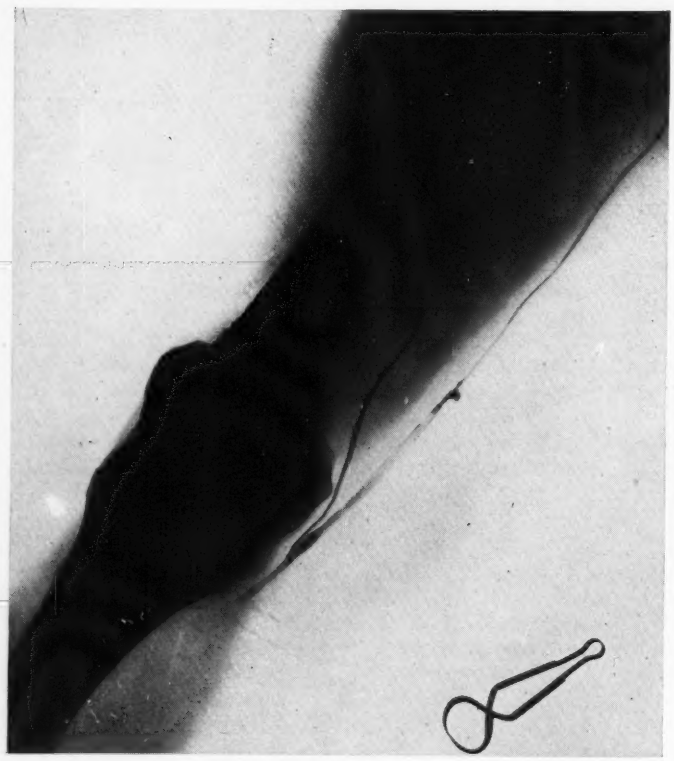

FIG. 421.—2 c.c. of dye injected down catheter in great saphenous vein. More than half of the fluid can be seen lying in deep or communicating channels.

Films exposed at varying intervals after completion of the injection showed the dye to remain longest in the varicosities, to pass more rapidly out of the communicating veins, and still more rapidly along the deep veins. These time relations were studied in further detail when serial pictures of direct injections of calf varicosities were made.

Sclerosing fluid is sometimes injected down the small saphenous vein when this is divided and tied in the popliteal fossa. Venography performed at operation on two cases with gross varicosities in this system with clinical evidence of incompetent valves showed that the dye passed downwards for no more than one inch before entering the great saphenous system by means of lateral communications.

2. Fluoroscopic Screening.—Therapeutic injections of varicose veins in the calf were imitated, using opaque dye and observing its behaviour with the fluoroscopic screen. Similar injections were made into normal veins. This was done with the patients standing, the method in most general use, and also using a tourniquet and ' empty vein technique '.

Screening Report 1 : Male, aged 25. Varicose veins left great saphenous system. Valves in great saphenous vein incompetent. With the patient standing, 2 c.c. of dye were injected into a vein in the middle of the calf and observed with the fluoroscopic screen. The fluid sank at once into the veins around the ankle. Smaller quantities of dye injected did the same.

The patient was now made to lie down and a similar injection of 2 c.c. made with a pneumatic tourniquet applied to the thigh. The dye spread in either direction along the vein over a total extent of 10–12 in. while the injection was being made: it then remained absolutely stationary until the patient moved his leg. The procedure was repeated with smaller amounts of dye and also using the 'empty vein' technique whereby injection was delayed after insertion of the needle until the tourniquet had been deflated and the veins emptied of blood. On every occasion the effect was the same: the dye remained at the area of injection until the patient moved his leg.

These findings were confirmed by similar procedures in other patients.

In a normal leg it was found that the dye never moved distally.

Screening Report 2: Male, aged 30. Normal leg veins. Standing with venous tourniquet on thigh, 1 c.c. dye injected into vein in mid-calf area passed only in a proximal direction. The muscles of the leg were contracted vigorously. The dye passed to some extent sideways around the leg by collateral branches, but none passed distally.

The procedure was repeated, varying the amounts of dye, but always with the same result: there was no distal flow of injected dye even with the tourniquet in place.

On removing the tourniquet the dye passed proximally at once and vanished within a few seconds. (*Fig.* 422.)

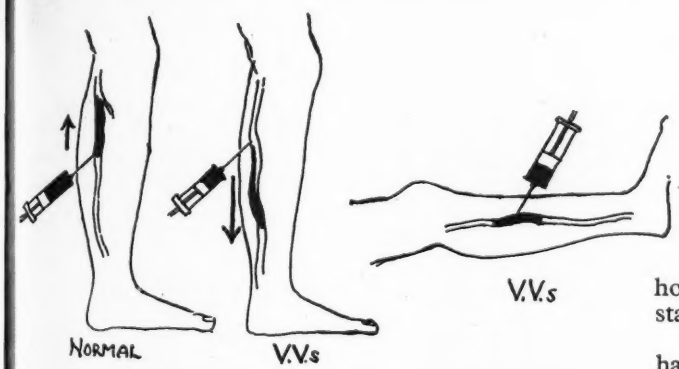

FIG. 422.—Fluid injected into normal leg veins will not pass distally. Injections into varicose veins flow towards the ankle if the patient is standing, but remain where injected if the leg is kept horizontal.

3. Serial Venography of Direct Injections of Varicosities in the Leg.—Forty venograms were made using a cassette tunnel so that serial pictures could be taken without moving the patient's leg. It was possible by this means to study: (*a*) the amount of fluid which could be injected without spilling over into the deep veins; (*b*) which veins were so situated that this spilling might occur; and (*c*) how long injected fluid would remain in the different components of the venous tree.

It is impossible to describe all of these observations in detail or to reproduce all the venograms. The main conclusions are as follows:—

a. From 1 to 1·5 c.c. is the optimal amount of fluid for an individual injection. Larger amounts tend to spill over into the deep veins. *Fig.* 423 shows an injection of 4 c.c. of fluid: about half of this has passed at once through a deep communication.

b. Entry to the deep veins is particularly likely to occur in tributaries of the small saphenous at the back of the leg.

c. Serial pictures of the same injection confirm what was found on screening—that an injection made into a superficial varicosity with the limb horizontal and at rest remains almost completely stationary until the limb is moved.

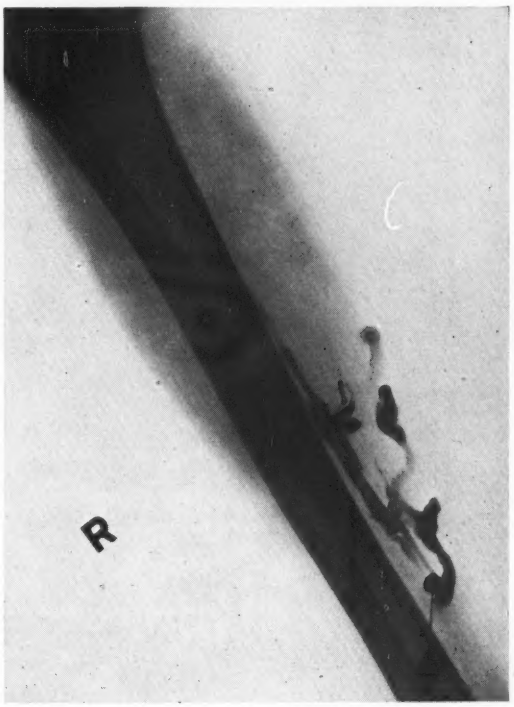

FIG. 423.—4 c.c. injected. Leg horizontal. Half the fluid has passed into the deep veins.

Figs. 424, 425 illustrate such an injection. There has been no significant flow after a minute and no dye has entered the deep veins. The amount used was 1·5 c.c.

d. Fluid passing into the deep veins remains there longer than might be expected; it is not swept instantly away, but may often be seen lying in some concentration a minute or more after injection. *Figs.* 426, 427 illustrate this point.

The fluid remains for a longer time still in the communicating veins and there is a tendency for it to linger in the neighbourhood of valves, as is shown in *Figs.* 428 and 429, which are part of a series of pictures taken of a small amount of dye passing up the popliteal and femoral veins.

Many of the venographic studies suggested that the methods of injection therapy in common use might lead to damage to valves or intima in the deep or communicating channels, particularly the latter. This might occur without permanent obliteration and might leave them with incompetent valves. Histological studies were therefore undertaken to investigate the effects of small doses of sclerosant.

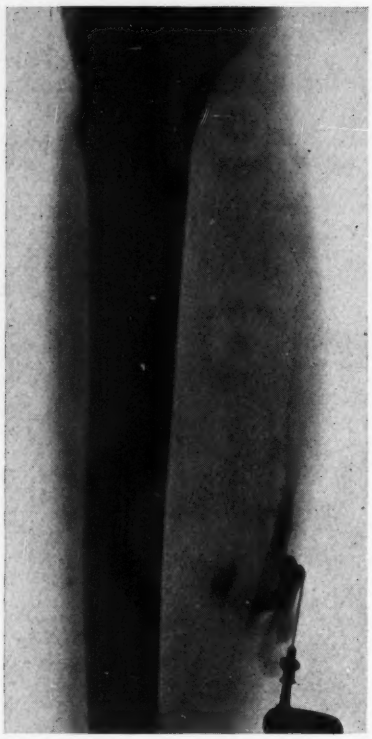

FIG. 424.—1·5 c.c. fluid injected with the leg horizontal. No fluid in deep veins.

FIG. 425.—The same injection as in *Fig.* 424, but one minute later. Negligible difference. An ideal injection.

Fig. 426

Fig. 427

FIG. 426.—2·5 c.c injected. Leg horizontal. High proportion of dye in popliteal vein.

FIG. 427.—Same injection as in *Fig.* 426, but one minute later. There is still marked concentration of dye in deep and communicating veins.

HISTOLOGY

Seventy sections were made of veins removed from 18 patients who were undergoing operation for extensive varicose veins. A short length of vein

Fig. 428

Fig. 429

FIG. 428.—Small amount of dye flowing up the popliteal and femoral veins: note concentration at valves.

FIG. 429.—As in *Fig.* 428, but 30 seconds later. Note that maximum concentration of dye occurs at valves.

was excised either at the groin or near the knee where division and ligature is usually carried out. Wherever possible a portion of vein containing a valve was removed. Most of these patients were given a small injection of sclerosant at times varying from one to six days before operation. The dose was one which would be inadequate to produce a satisfactory clinical 'take' as judged by tenderness or palpable thrombosis twenty-four hours after injection. Usually about 0·5 c.c. of 'Ethamoline' was used. Significant findings in these studies were as follows :—

1. *Uninjected veins:* The valves are extremely fine and delicate structures consisting of fibrous tissue covered by a thin layer of endothelium. *Fig.* 430 shows a section of an uninjected vein and valve. The valve is extremely thin compared with the vein wall. Such structures must be very vulnerable.

FIG. 430.—Section of uninjected vein through valve. Note delicate structure of valve in comparison with the muscular vein wall.

The walls of the veins examined were found to contain an impressive amount of muscle. There was no evidence of the stretched fibrous tissue which is sometimes stated to replace muscle in varicose veins.

2. *Injected veins:* Portions of vein were removed at operation from the neighbourhood of the injection. On naked-eye examination surprising changes were found in cases where no clinical 'take' had occurred. Walls and perivenous tissue were often œdematous, and adherent clots were found in the lumen, particularly in the ampullæ and regions of the valves. On microscopy the valves were found to have undergone cloudy swelling and sometimes inflammatory cell infiltration: they were often involved in adherent thrombus. The clot consisted of red cells and scattered patches of leucocytes in fibrin. The intima was often swollen, and œdema and areas of inflammatory cell infiltration were present in the walls.

Figs. 431, 432 illustrate some of these findings. They are sections of veins which had been injected but in which no signs of clinical 'take' resulted.

FIG. 431.—Section showing part of a valve involved in adherent clot in a vein injected with small amount sclerosant three days before operation. A clinical 'take' had not occurred.

FIG. 432.—Section of vein injected without signs of clinical 'take' resulting. Note intramuscular œdema, swelling of intima, and adherent clot in one side of vein lumen.

TREATMENT

In the light of the X-ray and pathological studies described, the following suggestions are made :—

1. For the more severe cases with incompetent great saphenous valves: high ligature at the

sapheno-femoral junction combined with ligature at knee level or in the thigh if communicating vein 'blow-outs' are detected.

Mass retrograde injection is an inaccurate and often a harmful technique and should be abandoned. Calf varicosities may require injection, which is best done at a later date. Should it be performed at the time of operation, the precautions described below for local direct injection should be taken.

2. Milder cases not requiring operation: the varicosities should be injected using an empty vein technique with the limb horizontal. A pneumatic cuff is inflated on the thigh and the needle inserted into a full vein. The cuff is then deflated and the injection made into an empty vein so that the sclerosant may act in maximum concentration; 1·5 c.c. is the largest amount advisable for an individual injection, and sclerosants which require larger volume doses should be avoided. The patient should not move the leg for at least five minutes after the injection. The limb should then be elevated, massaged, and moved vigorously to sweep the sclerosant rapidly away to be diluted in the general circulation.

SUMMARY

1. The rationale of injection treatment is discussed.

2. X-ray investigations in which therapeutic procedures were imitated with opaque fluid suggest that certain of them may allow sclerosing solution to damage deep, communicating, or other veins without producing permanent obliteration.

3. Histological studies of veins injected with sclerosant indicate that valves in particular may be damaged by doses too small to cause permanent obliteration.

4. Some technical points are described which are designed to avoid injury to deep or communicating veins when injection of the varicosities is undertaken.

We wish to thank Professor J. Paterson Ross for his very kind help in the preparation of this paper.

SPONTANEOUS HERNIATION THROUGH THE TRANSVERSE MESOCOLON

A REVIEW OF THE LITERATURE AND THE REPORT OF A CASE

By H. W. GALLAGHER, Banbridge

Spontaneous herniation through the transverse mesocolon is a rare but important condition. Its importance lies in the fact that unless the surgeon, confronted by an apparently inextricable tangle of abdominal viscera, is aware that such a condition can exist, he may be forced to close the abdomen without recognizing or treating the condition (Pringle, 1919). It is also important because when the hernia causes symptoms, usually obstructive, the mortality is high.

In 1934 Menegaux presented a comprehensive description of the condition, basing his work on 50 published cases, and added one personal case. During the next few years cases were published fairly frequently, and in 1939 Constantinescu and Popescu, in reporting two post-operative cases following gastro-enterostomy, were able to refer to 79 cases of the spontaneous and post-operative varieties. In the same year Yovanovitch, Boukourov, and Dragoyévitch, in adding a personal case, refer to 8 other spontaneous cases reported since 1934 or not included in those listed by Menegaux.

The purpose of this communication is to review the published cases, to collect those which were not reviewed by Menegaux or by Yovanovitch and others, to add a personal case, and to describe the condition more fully than has hitherto been done in English.

Frequency.—Mayo, Stalker, and Miller (1941), in a review of 39 internal herniæ surgically treated in the Mayo Clinic, refer to 10 cases around the stoma of a previous gastro-enterostomy, in 6 of which the herniation was into the lesser sac. There were no cases of the spontaneous type, which they consider is exceptionally rare.

Loebl first described the condition in 1844, and now, more than a century later, the present author can find only 70 published cases, although no doubt there are a few others which he has been unable to trace.

Age and Sex.—Of the 52 cases in which the sex of the patient is mentioned, 36 were female and 16 male. In 53 cases the age is given and varies from 17 days to 70 years, more than one-third of them occurring in the fourth decade.

Anatomy.—There are two main varieties of the hernia: (1) Those in which the herniated viscus is covered by a sac derived from the transverse mesocolon. (2) Those in which there is a breach in

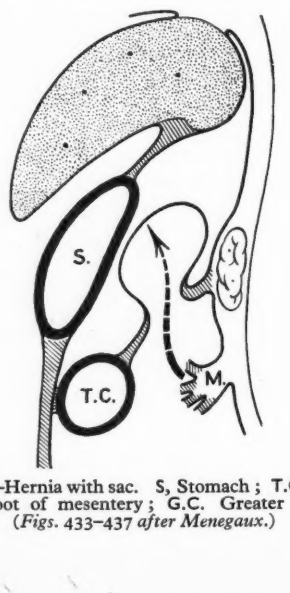

Fig. 433.—Hernia with sac. S, Stomach; T.C., Transverse colon; M, Root of mesentery; G.C. Greater curve; L.C., Lesser curve. (*Figs.* 433–437 *after Menegaux.*)

the continuity of the transverse mesocolon through which a viscus has passed.

It has been pointed out by previous authors that the absence of a sac means that the term ' hernia ' is a misnomer. However, as it describes the condition fairly accurately and succinctly and is in accord with other forms of internal hernia, the term has been generally accepted.

1. *Hernia with Sac.*—The anatomy of the variety is most easily depicted by diagram (*Fig.* 433).

2. *Hernia without Sac.*—There are two main types of this variety and they may coexist, giving a third type: (*a*) Herniation into the lesser sac, the herniated viscus being most frequently small gut; (*b*) Herniation of the stomach through the mesocolon; (*c*) A combination of the above.

The *orifice* is almost invariably in that part of the mesocolon which is relatively avascular, lying to the left of the mid-colic artery. Rodney Smith (1945) has described one case in which the orifice was almost at the hepatic flexure. In this case the length of herniated small gut was relatively short compared to the length which can herniate through the mesocolon into the lesser sac.

The orifice is usually very large, extending from the base of the mesocolon to the vascular arch in the neighbourhood of the colon, and has been described as oval, linear, and triangular with the apex nearer the gut. Its edge has been described as firm and almost rigid (Loebl, 1844, quoted by Menegaux, 1934, and Mayo, 1909); but more frequently it is thin and filmy, with large blood-vessels running along or close to and parallel with the free border.

In the variety with sac the *herniated viscus* has always been part of the small bowel. In the variety not covered with a sac, the stomach is the only viscus that can pass downwards; but in the more frequent herniation into the lesser sac, small bowel is most frequently involved and may be completely herniated. Involvement of cæcum and part of ascending colon, the transverse colon, and the sigmoid colon have all been described.

If a sac is present, it may be very large and displace the gastrocolic or gastrohepatic omentum. In the variety not covered with a sac the herniated bowel may remain in the lesser sac, which enlarges considerably. Betto (1938) and Tanner (1945) mention the possibility of the two leaves of an incompletely fused great omentum separating to accommodate the bowel, but such a case has not hitherto been described. In one of the cases reported by Pringle (1919) in which the small gut had escaped from the lesser sac through the gastrocolic omentum, the two leaves of the great omentum were not fused. In the same paper there is recorded a case in which a mesocolic orifice was present without herniation and in which the two leaves of the great omentum were also incompletely fused.

The viscera may escape from the lesser sac through the foramen of Winslow, the gastrohepatic omentum, or gastrocolic omentum (*Fig.* 434).

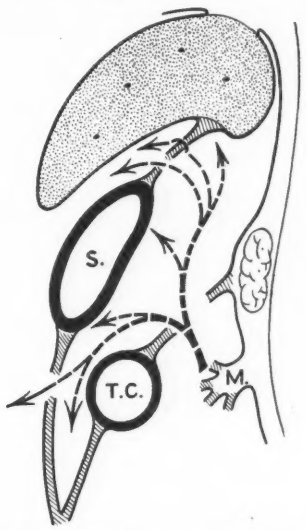

FIG. 434.—Hernia without sac. The arrows indicate the possible positions for the gut to assume, once the hernia has been established.

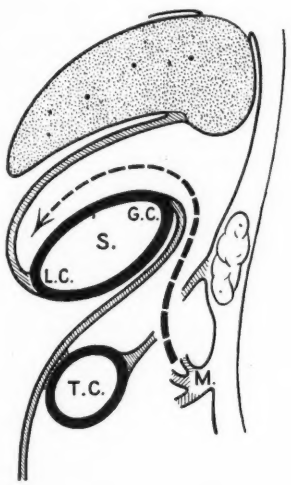

FIG. 435.—Volvulus of the stomach, first stage. The small intestine by pressure on the gastrohepatic omentum has caused the stomach to rotate 180° around a horizontal axis.

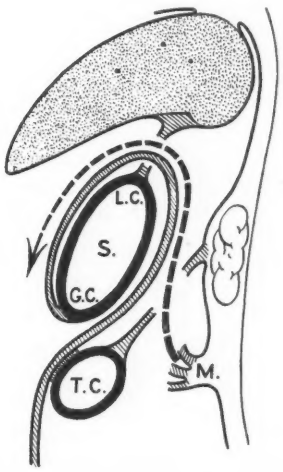

FIG. 436.—Volvulus of the stomach, second stage. The rotation has continued and is now 360°. The gastrohepatic omentum has ruptured.

By pressure on the gastrohepatic omentum, a volvulus of the stomach may be produced. This has been described twice, and the mechanism is well seen in *Figs.* 435, 436.

When the stomach alone is involved in the hernia, it appears to be a simple prolapse of part of the organ through the orifice; but when herniation of the small gut is associated with prolapse of the stomach, volvulus of the stomach may again occur. This time the lesser curve rotates posteriorly (*Fig.* 437).

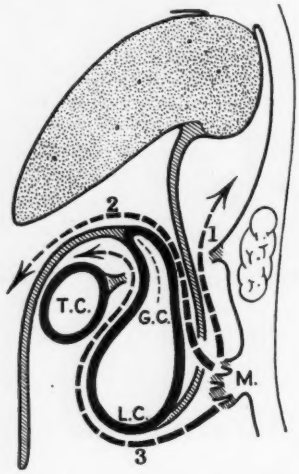

FIG. 437.—Hernia of stomach through the mesocolon. The stomach has rotated 180° in a horizontal axis, but in a different direction. The gastrohepatic omentum has ruptured. The arrows indicate possible positions for the small gut. The variety indicated by (3) has not been observed.

Associated Lesions.—By far the commonest associated lesion is a peptic ulcer, which may be active or actually perforated. This association has been noted in about 50 per cent of cases. Barrett (1935) considers that the ulcer is more likely to be the result, and not the cause, of the hernia. Other authors, however, consider that the ulcer is important in the aetiology of the condition.

Mayo (1909) and Strong Heaney and Simpson (1925) have drawn attention to associated visceroptosis, and in their opinion it is important in the aetiology of the condition.

Purely coincidental lesions have been carcinoma of the pancreas, perforated appendix, obstruction of small bowel by a band, abdominal hydatid cysts, and umbilical hernia.

Formation of the Orifice.—Trauma, apart from operative trauma, which is not considered here, has been responsible for one published case (Lombard, 1923, quoted by Menegaux). This patient had received a compression injury to the abdomen, and when operated upon for intestinal obstruction, it was noted that small gut had passed through a recent tear in the mesocolon and had strangulated.

Various theories have been put forward to account for the formation of the orifice, but absorption of an avascular area is now generally accepted as the cause. Various stages in the absorptive process have been noted—extreme thinning, multiple small holes, and the presence of an orifice without herniation (Pringle, 1919; Halpert, 1940).

Menegaux considers that absorption also accounts for the formation of the sac. He states that the lower, developmentally vascular layer of the mesocolon absorbs in an avascular area and the developmentally avascular upper layer is stretched over the invading gut.

The possibility that the opening is developmental has been put forward (Barrett, 1935; Mayo, Stalker, and Miller, 1941; and others) but, as Pringle (1919) and Menegaux (1934) point out, this is unlikely because the mesocolon is developed in two layers. One case which occured in infancy (Gjorup, 1933, quoted by Menegaux, 1934) suggests a developmental abnormality, but in this case the absorptive process may have progressed rapidly.

It has also been suggested that previous trauma may have torn the mesocolon and that the hernia gradually develops.

Production of the Hernia.—Mayo (1909) noted that his two cases occurred in patients with Glénard's disease, each having a dilated, ptosed, obstructed stomach. He considered that the vomiting due to the pyloric obstruction was responsible for the herniation; the gastroptosis leaving the transverse mesocolon unprotected, pressure exerted by the abdominal muscles can then force the small bowel into the lesser sac through the mesocolon.

Strong Heaney and Simpson (1925) elaborated this thesis and pointed out that the almost invariably associated ulcer produced fixation of the stomach, thus preventing its protection of the mesocolon.

Menegaux considers that this pulsion theory is not complete. He points out that in 1929 Godard and Smith reported a case in which they saw the hernia recur while the patient was on the operating table. This phenomenon has also been noted in a paraduodenal hernia by Park (1945). For this reason Menegaux considers that aspiration by the pump-like action of the diaphragm plays a large part in the production of the hernia. Fixation of the stomach by an ulcer produces a funnel and so exaggerates the aspiration effect of expiration.

Symptomatology.—The hernia may be absolutely symptomless and may only be discovered accidentally at post-mortem examination or at operation for some other condition. However, the hernia itself may cause symptoms practically indistinguishable from peptic ulcer, "... the dyspepsia or even the hæmatemesis may result from the hernia, for a history of dyspepsia is not unusual with hernia into the lesser sac no matter what route of entrance to it the bowel may take" (Tanner, 1945).

Chronic dyspepsia, acute obstruction, chronic obstruction, and recurrent self-relieving obstruction have all been described, and acute obstruction and perforation of an associated peptic ulcer have occurred together (Petridis, 1935).

Clinical Diagnosis.—Pre-operative diagnosis must be extremely rare. Acute obstruction associated with a resonant abdominal tumour may lead one to suspect an internal hernia.

In the less acute case radiology may be a help. Pfanner and Staunig (1921, quoted by Menegaux) have described a case in which the condition was pre-operatively diagnosed by radiologically demonstrating loops of small intestine above the lesser

curve of the stomach. In the opinion of Menegaux this is the only sure method of diagnosis, but small gut can occupy the right anterior intraperitoneal subphrenic space without mesocolic herniation being present. Crymble (1914) found this abnormality in 4 of 56 cadavers. In each case it was associated with some peritoneal variations or excessive distension of some viscus.

Other internal herniæ have been diagnosed pre-operatively radiologically. Archer and Cooper (1941) have demonstrated paraduodenal herniæ and Bosch and Schinz (1940) present the X-ray appearances, abnormality. If any difficulty in diagnosis is encountered then complete evisceration of the small gut will demonstrate the abnormal opening in the mesocolon.

Treatment.—If the condition is found, then it should be corrected unless, as in the case reported by Tanner (1945), the hernia is an accidental finding during operation for some other abdominal emergency and it is obvious that the hernia is not causing symptoms.

In all other circumstances the hernia should be reduced and the rent in the mesocolon repaired.

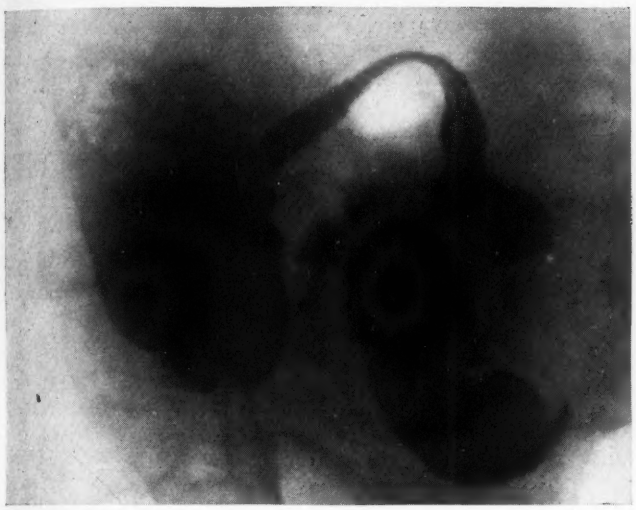

FIG. 438.—Barium meal at 6 hours, showing loop of terminal ileum.

FIG. 439.—Barium enema after evacuation (retouched), showing proximal transverse colon lying parallel with ascending colon and then looping up towards the splenic flexure.

after the administration of an opaque enema, of herniation of the hepatic flexure into the lesser sac through the foramen of Winslow.

Archer and Cooper stress the importance of taking frequent films following administration of an opaque meal to demonstrate the position of the small gut. In this way coils of small gut may be noted above the lesser curve of the stomach. In the present case it was noted that the terminal ileum ran obliquely downwards and laterally to the cæcum (*Fig.* 438), that the proximal part of the transverse colon was parallel with the ascending colon (*Fig.* 439), and that there was obstruction to the flow of barium in the colon just distal to where the transverse colon looped upwards from the cæcum to run towards the splenic flexure. It is suggested that, by the administration of an opaque enema when the deformity of the terminal ileum was noted, it should have been possible to demonstrate the ileum looping over the colon. It should be possible to demonstrate this looping in those cases in which the small gut descends in front of the transverse colon after having either left the lesser sac through the gastrocolic omentum or opened the leaves of the great omentum.

Operative Diagnosis.—If the condition is unsuspected or if the possibility of such a condition occurring is not known, then the operative diagnosis may be very difficult. Pringle (1919) closed the abdomen in his first case, not having recognized the Reduction is easy because of the absence of adhesions. In only a few cases have adhesions been noted, but they caused no difficulty in reduction. When acute obstruction has occurred the reduction may be difficult, if not impossible.

The closure of the orifice can be a much more difficult procedure because frequently it is triangular in shape, and has a thin friable edge in which run important vessels. At the apex of the triangle the edges can be approximated easily, but towards the base closure becomes more and more difficult. If the vessels are actually in the edge of the opening then closure cannot be effected by this method. For these reasons Menegaux advises that the edges should always be sutured to the posterior wall of the stomach, as practised by Pringle (1919). This procedure can be accomplished no matter what position the mesocolic vessels are in as the sutures can easily take a bite of mesocolon farther from the edge than the vessels. The importance of this is stressed because had this method of closure been effected in the present case recurrence would probably have been prevented.

If the hernia has escaped from the lesser sac through an abnormal opening, then such opening and any other accidentally made during the manipulations should be closed in the usual manner. Non-absorbable sutures should be used throughout.

Prognosis.—Menegaux (1934), in comparing this condition with the post-operative variety, has

stated that in the spontaneous type diagnosis is difficult but the outlook is good, and that in the post-operative variety diagnosis is easy but the outlook is grave.

The post-operative hernia usually manifests itself a very short time after the initial operation, but symptoms have occurred as many as twenty-eight years after a gastro-enterostomy (Constantinescu and Popescu, 1939). It is possible that this hernia was present for many years and only gave symptoms after a long interval. No case of post-operative hernia not causing symptoms has been published. For this reason only the mortality figures of the spontaneous hernia causing symptoms should be compared with the post-operative variety, when it will be found that it is, at least, of equally grave prognosis.

In only 29 out of the total of 71 cases were symptoms actually caused by the hernia. In 23 of these in which the result of treatment is given, death occurred in 13 cases, in 2 of which, however, death was not due to the hernia. This gives a mortality of almost 50 per cent. Four of these fatal cases were discovered at post-mortem examination, but death was undoubtedly due to the hernia.

CASE REPORTS

Cases 1–51.—Referred to by Menegaux (1934).

Cases 52–60.—Referred to by Yovanovitch and others (1939).

Case 61.—*Hilgenreiner* (1910). Female, 48 years. Umbilical hernia for four years, lower abdominal pain and constipation for two years, and intestinal obstruction for three days. Colon herniated through mesocolon and obstructed. Reduction and repair of defect. Recovery.

Case 62.—*Cioran and Sima* (1935), quoted by Constantinescu and Popescu (1939). Small gut through mesocolon, strangulation, death.

Case 63.—*Barrett* (1935). Female, 45 years. Dyspepsia for about one year, preceded twenty years previously by pain and vomiting. Small bowel involved, escaped through gastro-hepatic omentum, causing hour-glass stomach. No ulcer. Relief of symptoms after reduction and repair of opening.

Case 64.—*Petridis* (1935). Male, 35 years. Two weeks' obstruction. Three days' vomiting. Herniation of all small gut through mesocolon and gastrocolic omentum and volvulus of herniated gut. Perforated gastric ulcer associated. Death.

Case 65.—*Pariset* (1938). Female, 36 years. Accidental finding at post-mortem examination.

Case 66.—*J. C. Christoffersen* (1940). Female, 40 years. Life-long dyspepsia. Previously treated by appendicectomy and pyloroplasty. Small gut through mesocolon. Reduction and repair of orifice. Complete relief of symptoms.

Case 67.—*Greco* (1940). (Paper not consulted.) Mesocolic hernia (intramesocolic type).

Case 68.—*Sugasti* (1944). (Paper not consulted.) Transmesocolic hernia with volvulus of herniated mega-sigmoid.

Case 69.—*Rodney Smith* (1945). Male, 30 years. Recurring abdominal colic for eight months. Herniation of loop of ileum through small opening in mesocolon 1 in. from hepatic flexure. Cure.

Case 70.—*Norman C. Tanner* (1945). Male, 56 years. Accidental discovery at operation for perforated gastric ulcer. Herniation of small gut through mesocolon and gastrohepatic omentum. Hernia not reduced as it was not causing symptoms. Death.

Case 71.—*Author's case.* J. McB., male, 47 years.

The patient first came under observation on March 2, 1947, when he was admitted to hospital complaining of crampy abdominal pain of two days' duration associated with vomiting and constipation. He gave the history of having had "stomach trouble" for thirty years, the symptoms having been gnawing epigastric pain occurring about one hour after food and relieved by vomiting. The pain recurred with the periodicity associated with peptic ulcer. He had been in various hospitals ten, fifteen, and twenty years previously and each time, after the usual investigations for peptic ulcer, had been placed on a diet and had improved considerably. In addition to this ulcer type of pain he later stated that for the past thirty years he had not eaten a decent meal because solid food would give him a mild abdominal crampy pain, sometimes associated with vomiting.

He was undersized and undernourished, with sunken cheeks and a gross thoracic kyphosis. His abdomen was slightly distended and moved freely with respiration. There was some tenderness in the umbilical region, but no rigidity. Very soon after admission he passed flatus per rectum and his symptoms were completely relieved by an enema. X-ray examination after an opaque meal showed a stomach of normal outline and motility. The duodenal cap was slightly irregular, but not tender. At 6 hours the head of the meal was in the right colon and the tail in the terminal ileum, which was running downwards and to the right to join the cæcum. The significance of this was not appreciated until operation. A fractional test-meal revealed gastric acidity within normal limits.

On March 14 he had an attack of lower abdominal pain associated with an increase in bowel sounds. On March 25 he was examined radiologically after the administration of an opaque enema. The colon filled easily and showed no evidence of stenosis or obstruction. Emptying was complete.

Because of the previous history of relief by dieting, etc., he was kept on an 'ulcer régime' and discharged on March 29 somewhat improved.

He was readmitted on Sept. 25, 1947. Since his discharge from hospital six months previously he had had recurring attacks of abdominal cramps not associated with vomiting and occurring twice or thrice a week.

Constipation had become increasingly marked; he had developed hæmorrhoids and had noted that the pain was associated with abdominal distension. He was admitted during one of the attacks and prior to admission his own doctor had noted peristalsis travelling across the abdomen from right to left. The obstruction passed off shortly after admission. Radiological examination after an opaque meal showed that there was a hold up in the transverse colon for at least thirty hours and that the proximal part of the transverse colon was parallel with the ascending colon. A few days later he was again radiologically examined after the administration of an opaque enema. The enema flowed in normally to the splenic flexure. The transverse colon was very slow to fill and while it was filling the whole left colon ballooned to gigantic proportions. The right colon filled at the same time as this ballooning and was greatly distended. The colon appeared to fill the entire abdomen and no filling defect was noticed, but twenty-four hours later the right colon was distended with barium.

Intermittent obstruction of the transverse colon of unknown aetiology was diagnosed and an exploratory laparotomy was performed on Oct. 16, 1947, under general anæsthesia. The abdomen was opened through a right rectus-splitting incision. Omentum covering coils of small gut presented and to the right the cæcum, ascending colon, and proximal part of the transverse colon were seen, the transverse colon then disappearing under the small gut. On attempting to elevate the omentum it was noted that its two leaves were separate and that the omentum enveloped small gut. The lesser sac was then opened through the anterior leaf of the omentum and it was confirmed that practically all the small gut was in the lesser sac, having access through a large opening in the mesocolon lying to the left of the mid-colic artery. Only the terminal few inches of ileum were in the general peritoneal cavity, running downwards and to the right to the cæcum (*Fig.* 438).

Adhesions between the cæcum and transverse colon were easily broken down and the transverse colon, which was now freely mobile, was elevated and the small gut easily reduced into the general peritoneal cavity. With the mesocolon stretched the hiatus was triangular in shape, the narrow base being at the base of the mesocolon. The mid-colic vessels were within a few millimetres of the right free edge and the whole mesocolon and omentum were almost completely devoid of fat.

The edges were approximated with interrupted catgut sutures, some difficulty being encountered at the base of the triangle. The opening in the anterior leaf of the great omentum was repaired in a similar manner, appendicectomy performed, and the abdomen closed. There was no sign of a peptic ulcer.

On Oct. 19 he developed what was taken to be acute dilatation of the stomach, which was relieved by gastric aspiration of large amounts of fluid and fluid replacement therapy. From Oct. 25 he had some abdominal pain relieved by enemata but by Oct. 31 the pain had become much more intense and enemata neither relieved the pain nor produced a result.

On that date a second operation was performed for the relief of this obstruction. It was found that there was partial obstruction to the jejunum by a band and that part of the small gut distal to this had re-entered the lesser sac through the same opening as previously. Because of adhesions and distension of the herniated loops reduction was impossible and a side-to-side anastomosis was performed between a loop of the distended small gut and the pelvic colon over the collapsed transverse colon. Following this he received two pints of blood and more intravenous fluid and he passed copious fluid stools.

On Nov. 6 he again showed signs of intestinal obstruction but was practically *in extremis*, and next day fluid fæces escaped from the operation wound and he died soon after. No post-mortem examination was performed.

Comment.—The possibility of recurrence was not considered on the third day. Had the second operation been performed then, in the early stages of the obstruction, or six days later when abdominal pain recurred, the outcome might have been successful.

At the second operation, division of the transverse colon with closure of the distal end and formation of a colostomy with the proximal end was considered. It was felt that satisfactory closure of the distal end would have been impossible because of the tension and difficulty in exposure due to the overlying dilated small gut. With all its risks, it would probably have been a better line of treatment.

SUMMARY

The anatomy of herniation through the transverse mesocolon is described and its aetiology and treatment are discussed. Short notes are given of cases reported since or not included in the classic reviews by Menegaux (1934) and Yovanovitch and others (1939) and one further case in which there was early recurrence is added.

I wish to thank Mr. G. F. Home and Mr. J. J. Graneek, of the Library of the Royal Society of Medicine and Queen's University Library, Belfast, respectively, and their staffs for help in obtaining various papers; Dr. G. T. N. Lawson for translation from the German literature; and Professor P. T. Crymble, who drew my attention to the fact that the small bowel may be above the level of the lesser curve of the stomach without having passed through the lesser sac.

The patient was referred by the late Dr. T. E. Reade.

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A CASE OF OSTEITIS FIBROSA CYSTICA

By EDGAR W. THOMAS, Macclesfield

This paper is being published for two reasons: (1) To reiterate the now well-known association between parathyroid tumour and osteitis fibrosa cystica; and (2) To illustrate, by X-ray photographs, the remarkable rapidity of recalcification which can occur after removal of such a tumour.

HISTORICAL SURVEY

1877: Sir James Paget first accurately described osteitis deformans as a definite pathological entity.

1891: Von Recklinghausen described a case of osteitis fibrosa and thought it to be a juvenile form of Paget's disease.

1904: Von Askanasy showed that an association existed between osteitis fibrosa cystica and the parathyroid gland.

1907: Erdheim described three cases of osteitis fibrosa cystica with parathyroid tumours.

1915: Schlagenhaufer described two cases of osteitis fibrosa cystica associated with parathyroid growths at autopsy and was the first to suggest a causal relationship.

1922: Weil tried radiotherapy to the neck in a case of osteitis fibrosa cystica.

Morton suggested the possibility of a disturbance of calcium metabolism in osteitis fibrosa cystica and thought the calcium level in the blood higher than normal.

1925: Hoffreitz collected many cases from the literature of association of osteitis fibrosa cystica with enlarged parathyroid glands.

1926: Collip isolated the parathyroid hormone and proved its function to be the regulation of calcium metabolism.

Hannon, Shaw, McClellan, and Du Bois found a high serum-calcium in cases of osteitis fibrosa cystica, with a rise of calcium and phosphorus output in the urine, and that the metabolic changes were those seen in a normal patient having 150 units of parathormone daily by injection. They concluded that such patients suffered from 'hyperparathyroidism'.

Mandl removed a parathyroid tumour with improvement in the 'bone-pains'.

1931: Hunter was the first to recognize the syndrome in Great Britain and he established parathyroidectomy as the correct treatment. He reviewed 22 cases.

Cases Recorded.—1934, 115 cases; 1936, 136 cases; 1938, 186 cases.

CASE REPORT

Mrs. R. J., aged 46 years, was admitted to West Park (County) General Hospital, Macclesfield, on May 15, 1945, with a fracture of the neck of the left femur following a fall thirteen weeks previously. She had spent six weeks in bed, was allowed up, but only walked with much pain.

X-ray examination on May 16 revealed an old-standing fracture of the neck of the left femur, with considerable disorganization of the neck, suggestive of a pathological fracture.

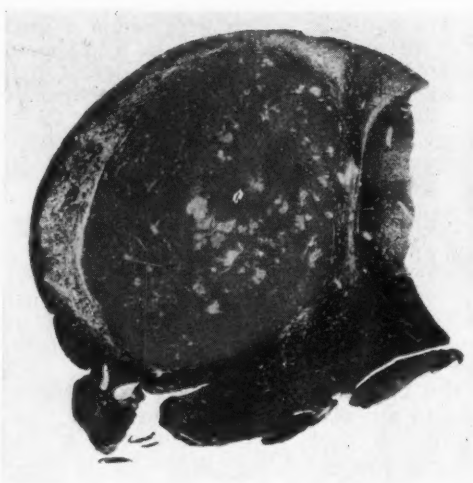


Fig. 440.—Section through tumour (*see* text).

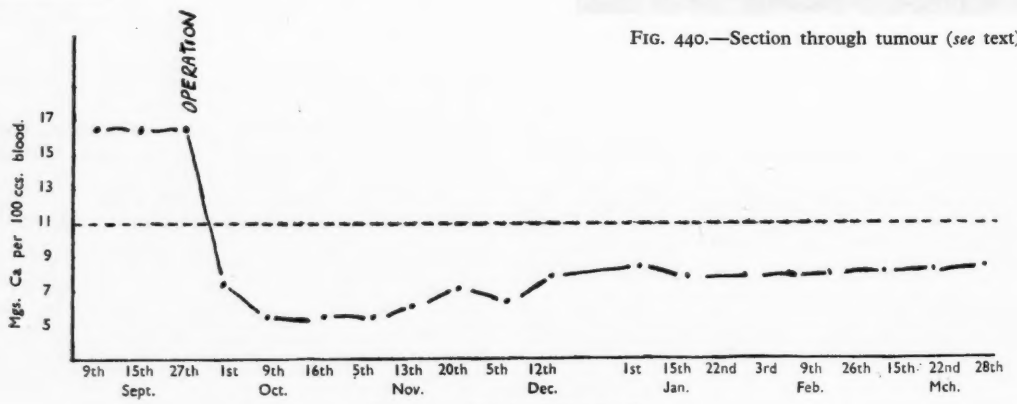


Fig. 441.—Blood-calcium levels.

The possibility of secondary metastatic deposit was considered, but no primary focus was found. Blood serum-calcium taken on May 22 was 11 mg. per cent. She was discharged on May 23 and readmitted on Sept. 1, 1946, with a fracture of the left humerus and left femoral shaft and radiographs taken on Sept. 4 showed non-union at left femoral neck, pathological fracture of upper third of shaft of femur, fracture of olecranon process of left elbow, and large cystic defects in the neck of left radius and upper third of left humerus. Picture highly suggestive of fibrocystic disease.

Sept. 9: Blood-calcium 16·7 mg. per cent
Blood-phosphorus 2·76 mg. per cent
Red blood-corpuscles 2,800,000 per c.mm.
White blood-corpuscles 7,000 per c.mm.
Hb 47 per cent
Urine calcium 29 mg. per cent
No Bence-Jones protein found

Sept. 11: Radiographs of skull, face, and pelvis show widespread fibrocystic disease.

Sept. 23: Two pints of concentrated red cells given by transfusion.

Sept. 27: OPERATION (E.W.T.).—Under general anæsthetic (Dr. Cope) the neck was explored through Kocher's collar incision. Thyroid gland normal in size and texture. Right lobe dislocated after ligation of superior thyroid artery and a tumour the size of a plum found *behind* the thyroid fascia and just above the inferior thyroid artery; removed after ligating its vascular pedicle. No tumour was found on the left side. Wound closed with drainage.

Naked-eye appearances of tumour: fleshy mass—adenoma of parathyroid.

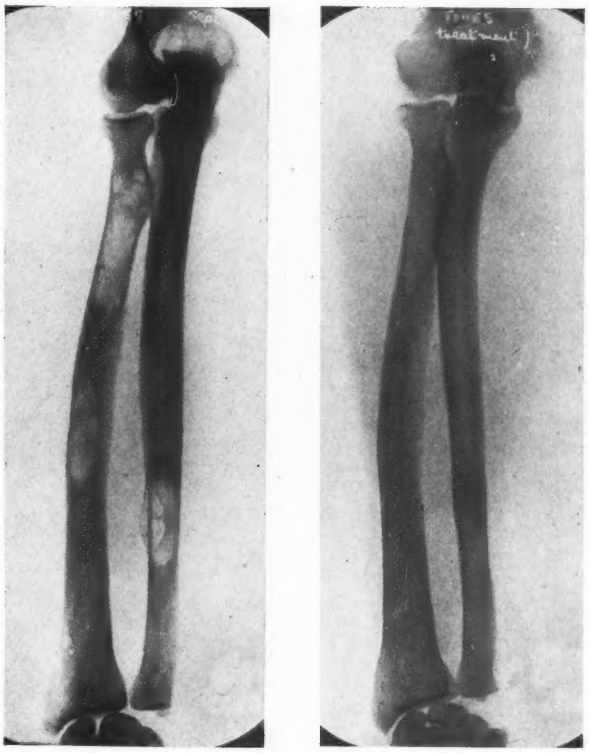
MICROSCOPICAL REPORT ON TUMOUR (Dr. Stafford).—Sections show a parathyroid adenoma 1·3 × 1·0 × 0·7 cm. in dimension, embedded in thyroid tissue (*Fig.* 440). The tumour consists of uniformly disposed cells, most with completely clear or vacuolated cytoplasm and others containing oxyphil granules, and there is a distinct variation in size of cells and nuclei. There are numerous irregular cavities filled with pink staining material of colloid appearance and without any definite vascular sinusoids. No definite fibrous capsule separates the tumour from surrounding thyroid tissue, but there is no infiltration or other evidence of malignancy. There is a small mass of parathyroid tissue quite apart from the adenoma in which the cells are much more uniform in size than those of the tumour.

POST-OPERATIVE COURSE.—This was uneventful except for a complaint of vague "funny feelings all over". She was given calcium lactate gr. 20 t.d.s. and parathormone 10 units daily.

Blood-calcium Levels.—See Fig. 441.

PROGRESS.—

Oct. 16: Fracture of shaft of left femur manipulated and a hip plaster spica applied.



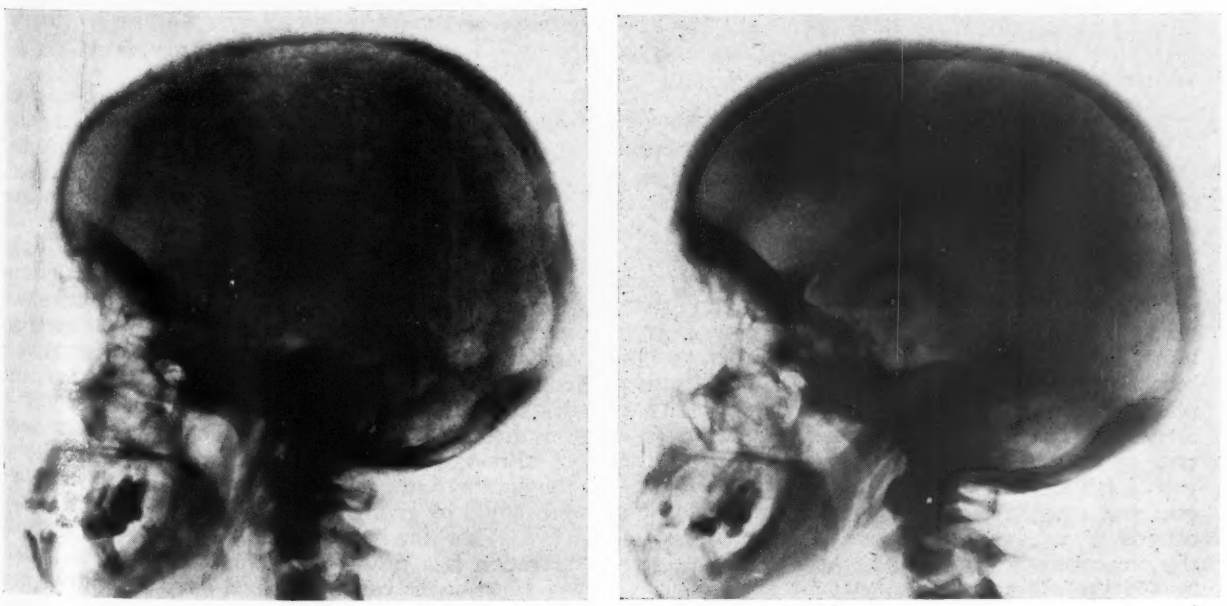
A B

FIG. 442.—Radiographs of radius and ulna. A, Pre-operative (Sept. 11, 1946); B, Post-operative (March 8, 1948).

Nov. 18: No significant change noted in radiographs of femur.

Feb. 2, 1947: Considerable recalcification of left femur shaft and pelvis noted. No union of neck. Weak union of shaft.

Aug. 4: Left femoral shaft united. Marked recovery in bones of skull and radius.



A B

FIG. 443.—Radiographs of the skull. A, Pre-operative (Sept. 11, 1946); B, Post-operative (Aug. 4, 1947).

A B

FIG. 444.—Radiographs of the left femur. A, Pre-operative (Sept. 11, 1946); B, Post-operative (July 30, 1947).

Aug. 8: Seen by Mr. Wainwright, orthopædic surgeon, who advised a Lorenz bifurcation osteotomy to left femoral neck.

Oct. 29: Subtrochanteric osteotomy performed and plaster spica applied to left hip.

Nov. 15: Discharged home.

Feb. 16, 1948: Plaster removed.

March 8: Walking with aid of a stick. Blood-calcium 8·5 mg. per cent.

X-ray Changes.—See Figs. 442–445.

DISCUSSION

The main clinical features of fibrocystic disease of bone are the slow onset, progressive character, bone pains, bone deformities, and spontaneous fractures. In differential diagnosis two main diseases to be excluded are multiple myelomatosis and secondary carcinomatosis of bone. This can usually be done by a consideration of the duration of symptoms, radiography of long bones and pelvis, and the biochemistry of the blood (serum-calcium, serum-phosphorus, and plasma-phosphatase). A rise of serum-calcium from the normal of 9–11 mg. per cent to 12 mg. or even 30 mg. per cent, together with a fall in the serum-phosphorus to 0·3 mg. per cent and a negative calcium balance, is diagnostic of osteitis fibrosa cystica. In myelomatosis we find the presence of Bence-Jones protein in the urine.

On the other hand, Lahey and Haggart (1935) have pointed out that hypercalcæmia and hypophosphatæmia may not consistently be found in suspected cases, particularly in those where there is severe renal damage. They classify the cases into three groups, viz.:—

1. Classical—characterized by osteoporosis and cyst formation.

2. Those in which renal pathology only is present and there are no X-ray changes.

3. Those in which renal calculi in the pelvis or tubules is the outstanding feature.

In some of Lahey's cases the blood serum-calcium was not in excess of 11 mg. per cent and yet a parathyroid tumour was found at operation. He suggested that many cases of osteitis fibrosa cystica were missed.

As regards aetiology, two main hypotheses have been put forward:—

a. That the parathyroid enlargement is compensatory to lack of vitamin D. This is partly supported by the fact that the disease is almost unknown in countries having a maximum of sunlight, e.g., Australia, whereas in North America it is comparatively common. Furthermore, the experiments of Goodale, Higgins, and Sheard tend to give further support to this theory. They showed that if chicks were deprived of ultra-violet light a compensatory hypertrophy of the parathyroid glands occurs, and that this could be prevented by giving parathormone injections.

b. That the primary cause of the parathyroid secretion is a pituitary dysfunction.

Most of the cases described have been in women (3 females to 1 male), and between the ages of 30 and 50 years, although Landon had one case in a child of 2½ years.

A B

FIG. 445.—Radiographs of the humerus. A, Pre-operative (Sept. 11, 1946); B, Post-operative (March 8, 1948).

Pathology.—Most pathologists agree that the pathological changes in the parathyroid gland are those of a hyperplasia rather than a true adenoma. Malignant tumours are very rare.

The bone changes are mainly resorption, new-bone formation, and cystic degeneration. The resorption is the result of halisteresis and absorption by osteoclasts. The ' new-bone ' formation is really the conversion of connective tissue into osteoid tissue but devoid of calcium. The end-result is a thickened structure composed of osteoid tissue in which areas of degeneration and hæmorrhage occur, with formation of cysts. Unlike Paget's disease, the bone resorption greatly exceeds the new-bone formation and the whole process is much more extensive and severe.

I wish to acknowledge my thanks to Dr. J. Blair Hartley for his keen interest and advice on the X-ray photographs and to Mr. Denys Wainwright for performing the osteotomy.

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TRAUMATIC FALSE ANEURYSM SIMULATING BONE SARCOMA

By DONALD C. BOWIE, Lt.-Colonel, R.A.M.C., and A. W. KAY, Major, R.A.M.C.

The case of this soldier shows remarkable X-ray appearances, and illustrates yet another pitfall in the diagnosis of bone tumours.

CASE REPORT

In November, 1946, the patient, aged 19, and previously perfectly healthy, was serving in North Italy when he was shot through the right leg. A revolver bullet entered the calf posteromedially and came out anterolaterally.

There was bleeding at the time, but this was not excessive, and the small entrance and exit wounds healed without operation. Radiography established that there was no bone lesion. The initial swelling of the soft tissues subsided in due course, but the patient's account of subsequent events varied. On one occasion he said that the leg became quite normal, whilst on another occasion he said that a slight degree of swelling persisted, and that at times he limped and experienced a throbbing sensation of short duration in the leg. Soon after the injury, however, he was able to carry out his full duties, and any disability which existed was slight, and did not prevent him playing football for his unit.

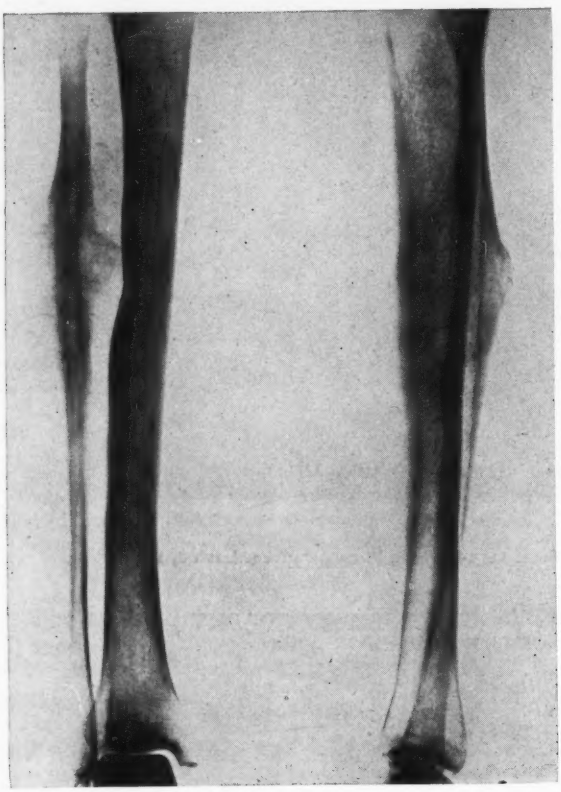

Fig. 446.—Radiograph, July 18, 1947, eight months after revolver bullet wound which caused no obvious bone lesion initially.

About July, 1947, a swelling appeared and increased in size quite definitely and fairly rapidly, but not suddenly, and formed an elastic, rather fluctuant swelling in the anterior compartment of the right leg. Radiographs taken on July 18, in Italy, gave the appearances shown in *Fig.* 446, and the soldier was invalided home as a case of suspected neoplasm. He was admitted to the Millbank Wing of the Queen Alexandra Military Hospital early in September by direction of Brigadier D. Fettes, Consultant Surgeon to the Army.

Here we found a rather pale, but not unhealthy looking, young soldier, in whom physical examination disclosed no abnormality beyond the local condition in the right leg.

In the anterior compartment of the right leg, occupying the upper middle third, was a painless swelling some 4 in. long in its long axis. This swelling did not merge into the tibia, but appeared to tail off to the outer side and be fixed to the fibula. The swelling was elastic, it was very faintly pulsatile, and was not tender. There was no audible bruit, nor palpable thrill; the overlying skin was not discoloured or fixed, and movements of the knee and ankle were quite free. The regional lymph-nodes were not enlarged, and the posterior tibial pulse was easily felt at the ankle, though the dorsalis pedis pulse was not felt. There was no sign of nutritional disturbance in the leg distal to the swelling.

The X-ray films gave the appearances shown in *Fig.* 447, and on these appearances a diagnosis of sarcoma was made. The help of Sir Stanford Cade and Dr. F. M. Allchin, of the Westminster Hospital, was sought, and, as always, readily accorded, and between Sept. 4 and Sept. 24 deep X-ray therapy was given to the affected part to a total of 3037 r.

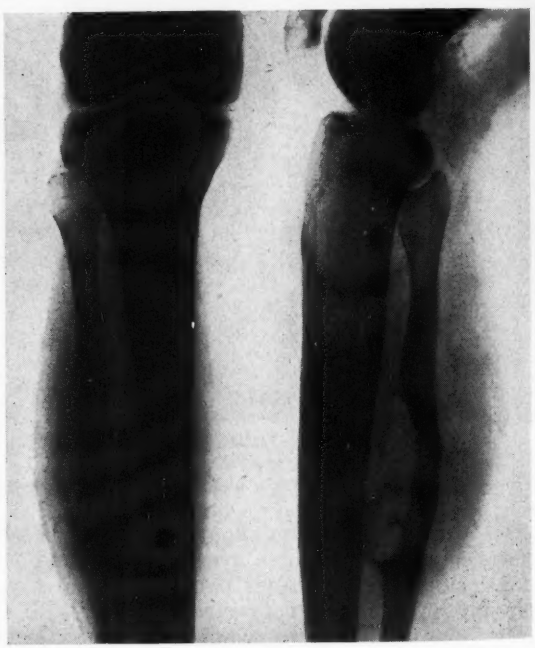

Fig. 447.—Radiograph, Sept. 20, 1947, ten months after revolver bullet wound.

The possibility of the appearances being the result of a traumatic aneurysm had been considered and arteriograms were done, with the result shown in *Fig.* 448.

Finally a number of very eminent consultants and teachers were shown the X-ray films reproduced as *Figs.* 447 and 448, without seeing the patient, and declared in favour of neoplasm.

At operation on Oct. 14, 1947, at Millbank, on separating the extensor digitorum longus and tibialis

anterior the finger passed into a cavity the size of a large hen's egg containing old blood-clot, which was readily scooped out, leaving a smooth shining endothelium-like lining of the cavity. The interosseous membrane was partly ossified and there was a slit-like wound of the posterior aspect of the anterior tibial artery, whence bleeding re-commenced when the tourniquet was loosened. No other vessels opened into this cavity.

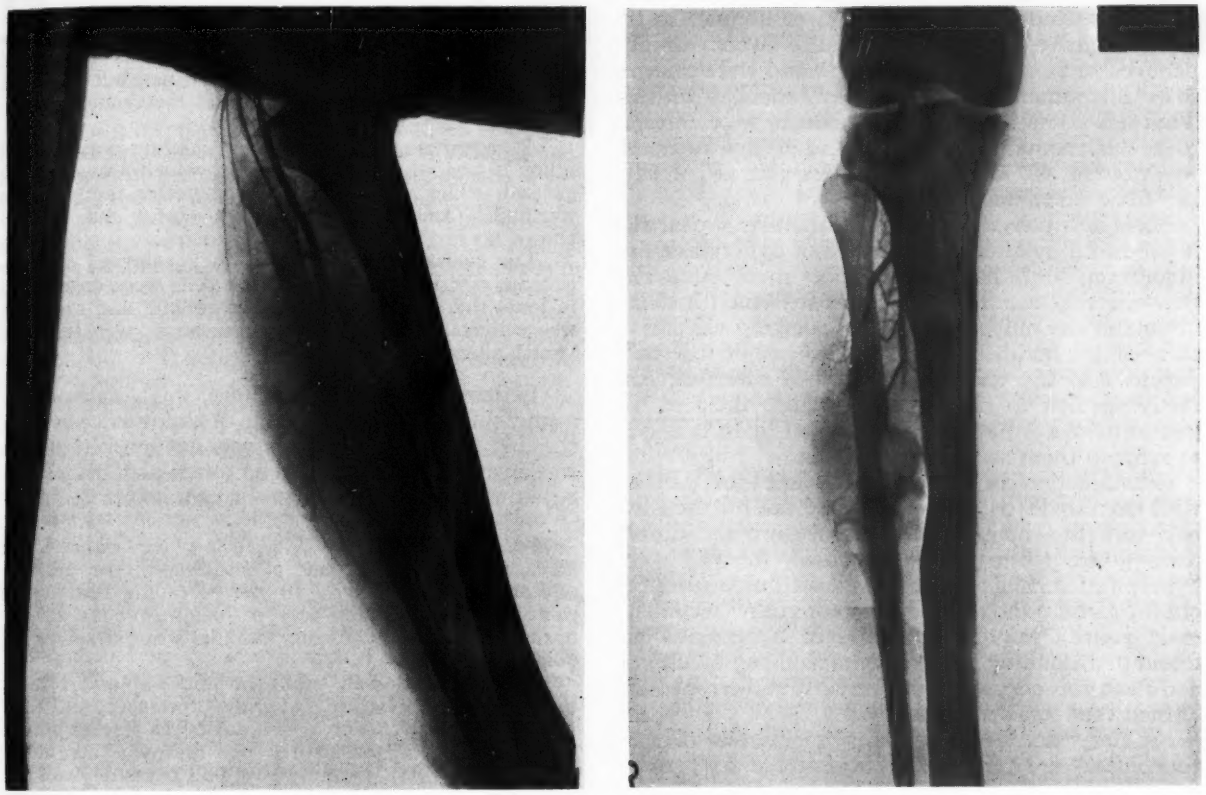

FIG. 448.—Arteriograms, Oct. 6, 1947, eleven months after revolver bullet wound.

The bleeding was controlled by direct ligation of the anterior tibial vessels, and the wound was closed. The clot showed a laminated appearance on section. We were, in fact, dealing with a traumatic false aneurysm, although the radiographs had suggested a much graver explanation of the bone appearances.

Discussion.—The X-ray appearances in *Fig.* 447 when we first saw the patient certainly suggested that we were dealing with a bone sarcoma. At this time, however, we had a reasonably healthy-looking patient who had no pain and little or no interference with function, in spite of the apparent extent of the lesion. These points together, though they by no means exclude a bone sarcoma, form a combination which is unusual in this condition. *Fig.* 446 reinforced the need for caution, for the appearances at that time show a tibia indented by pressure but not eroded, and a fibula which retained its essential structure in spite of the surrounding changes.

When the arteriograms are examined, the anterior tibial artery is seen to be occluded in both views; the peroneal artery is visualized throughout its length in the lateral view, and the posterior tibial artery is normal. In neither view is there any increase in the number of vessels around the tumour site to suggest a pulsating neoplasm. It could also be said that if the swelling is aneurysmal, the contained blood is clotted.

It would have been interesting to re-examine the X-ray films taken immediately after the injury in view of the subsequent ossification, but these were not available.

Pitfalls in radiological diagnosis are many, and it may often be wise when dealing with bone tumours to rest the diagnosis upon a liberal biopsy before embarking upon mutilating surgery.

SUMMARY

A case is described of a traumatic false aneurysm of the anterior tibial artery simulating a sarcoma of the fibula in a young soldier aged 19. Operation was followed by recovery.

We are indebted to Mr. J. H. Smitham and Mr. A. Pollock, of the Westminster Hospital, for the arteriograms.

It is a pleasure to acknowledge the wise advice and help we received from Brigadier D. Fettes, Consultant Surgeon to the Army, while, in this patient as with many other Army patients, the vast experience of Sir Stanford Cade and Dr. F. M. Allchin has been generously and unreservedly made available to us.

THE SOLITARY THYROID NODULE AND THYROTOXICOSIS

By H. L. M. ROUALLE

THE nomenclature of the different forms of goitre has, in the past, given rise to much confusion owing to imperfect understanding of the pathological processes involved in the production of nodules in the thyroid gland. All such nodules were at first believed to be neoplastic in nature and were referred to as ' adenomata ', particularly by American authors. Thyroids containing multiple nodules were referred to as ' adenomatous goitres ', and if thyrotoxicosis was present as ' toxic adenomatous goitres ' or even as ' toxic adenomas '.

It is now considered that this nodular appearance is produced by alternating phases of hyperplasia and involution, and that a distinction must be drawn between this condition and that in which a single nodule is the only pathological change. Certain of these single nodules have the character of true neoplasms and the term ' adenoma ' is therefore correctly applied to them; but because their pathological nature is not generally agreed upon it is best to refer to them as solitary nodules.

Examination of the thyroid glands of patients with thyrotoxicosis show that these fall for the most part into two main groups: these are the diffuse toxic goitre (primary toxic goitre), in which the hyperplastic changes are evenly distributed throughout the gland; and the nodular toxic goitre (secondary toxic goitre), in which patches of hyperplasia are found in a gland which also contains many involution nodules: this condition was formerly and erroneously termed the ' toxic adenoma '.

Solitary nodules (including a number of true adenomata) are frequently encountered in patients who demand their removal for cosmetic reasons, but it is unusual for such patients to evince clinical evidence of thyrotoxicosis.

In a recent review of 207 patients who had undergone operations for enlargement of the thyroid, thyrotoxicosis was present in 107 and a single nodule in 59, but only 4 patients showed a combination of the two (*Table I*).

Table I.—ANALYSIS OF 207 THYROID OPERATIONS
(Professorial Unit, St. Bartholomew's Hospital, 1938–47)

TYPE OF GOITRE	TOXIC	NON-TOXIC	TOTAL INNOCENT	MALIGNANT	TOTAL
Diffuse	72	3	75	—	75
Nodular	31	28	59	4	63
Single nodule	4	47	51	8	59
Lymphadenoid or ligneous	—	6	6	—	6
Metastasizing	—	—	—	4	4
TOTAL	107	84	191	16	207

CASE REPORTS

Case 1.—Miss V. S., aged 48, was admitted on March 25, 1947, complaining of discomfort on swallowing of about six weeks' duration, increasing nervousness, loss of weight of more than 14 lb. in the preceding year, palpitations, and headaches. She weighed only 6 st. 7 lb., and had a worried expression and a hot moist skin. A soft nodular swelling about 2 × 1½ in. appeared to involve the isthmus and left lobe of the thyroid gland. Her pulse-rate averaged 86 per minute, blood-pressure 150/92 mm. Hg, and her heart showed no clinical abnormality. The eyes appeared normal, but there was a fine finger tremor and her basal metabolic rate was + 14 per cent.

At operation, a large solitary nodule was exposed filling almost the entire left lobe, which was therefore excised. The right lobe appeared normal and was not touched. Convalescence was uneventful and she has shown no further signs of thyrotoxicosis.

The excised lobe, weighing 39 g., showed a homogeneous whitish cut surface: the cells were arranged as in fœtal thyroid, without acini or colloid, and the tissue was cellular and vascular. Appearances were those of ' fœtal adenoma '.

Comment.—Here, therefore, was a patient with a single nodule and symptoms of thyrotoxicosis. As the degree of thyrotoxicosis was not marked, search was instituted for records of other patients of this type and the following case histories were found:—

Case 2.—Miss D. W., aged 25, was admitted on Dec. 2, 1937, on account of swelling in the neck for 9 years and irritability. In the preceding few months there had been steady loss of weight (about 20 lb.), headache, tremors, sweating, and increasing dyspnœa and palpitations.

She appeared well built, but flushed and restless. Her skin was moist, eyes slightly prominent, and there was a fine finger tremor. The pulse was regular but the rate varied from 100 to 120 per minute; her blood-pressure was 158/95 mm. Hg. The thyroid gland was soft, but considerably enlarged.

At operation the enlargement was found to be entirely left sided and a single ' nodule ' was enucleated without difficulty from its false capsule. The rest of the left lobe appeared normal; the right lobe was not touched. The pulse-rate averaged 120 to 150 per minute at operation, rising later to 160. It then fell steadily until the eighth day, when it averaged 86 per minute. Her convalescence was uneventful and after ten years her weight remained unaltered, and there had been no further palpitations.

Section showed vesicles distended with deeply staining colloid with no evidence of hyperplasia: the surrounding gland tissue was compressed into a false capsule.

Case 3.—Miss E. W., aged 51, was admitted on Nov. 3, 1936, on account of dyspnœa, palpitations, and swelling of the ankles for six months. There had been no loss of weight, but a goitre had been present for about twenty years.

Auricular fibrillation was present, with an apex rate of 120 per minute and a pulse deficiency of 40 per minute. Blood-pressure was 164/80 mm. Hg. There was a firm smooth thyroid swelling about 2 in. in diameter involving the isthmus and left lateral lobe. The basal metabolic rate was + 18 per cent.

Rest in bed and iodine had no perceptible effect on her pulse chart, and operation showed a large single nodule which was enucleated from the apparently normal tissue behind it. The right lobe was not exposed.

The heart rate rose to the 146 per minute after the operation, but gradually fell till the sixth day when it

stabilized itself at 80 per minute with no pulse deficiency. Convalescence was uneventful and she has since remained well, with a normal pulse-rate and no evidence of thyrotoxicosis.

Unfortunately, there is no report on the histology of the nodule.

In contrast to these three patients, who exhibited a single nodule as their only pathological abnormality, and whose thyrotoxicosis was relieved by its removal, the history of another patient in whom the pathology differed, is appended.

Case 4.—Mrs. E. W., aged 67, was admitted on Nov. 1, 1944, complaining of shaking and loss of weight for ten months, amounting to over 6 st. A swelling had been present in her neck for about twenty years. Dyspnœa and palpitations occurred on exertion.

She was a nervous, fidgety woman, but without exophthalmos.

In the midline of the neck an obvious pulsatile swelling 1 in. in diameter could be felt, but the lateral lobes were not palpable. The pulse-rate averaged 106 per minute, the blood-pressure 202/90. The rate was not clinically enlarged, but a systolic murmur was audible over the whole precordium.

At operation, a large localized nodule was excised on the left side, but as the remainder of the gland appeared active and vascular, two-thirds of the right lobe and part of the left were excised.

Post-operatively, her condition rapidly improved, the pulse-rate falling within four days to 86 per minute. After two years, however, despite an increase in weight of 30 lb., palpitations and tremors recurred. She was found to have a pulse-rate of 120 per minute and the left lobe was still palpable. Further operative treatment has been recommended.

The tissue excised at operation showed: (1) a pale firm nodule, which was partly calcified, and which on section showed atrophic and degenerative changes but no evidence of activity; and (2) the remaining gland tissue, which appeared nodular, and which on section showed multiple foci of cellular hyperplasia and diminished colloid content.

Comment.—The relapse in the thyrotoxicosis despite removal of the original nodule indicates that it was not the cause of the symptoms, and that this patient should be considered as having developed a toxic goitre in a thyroid gland which already happened to contain an inert single nodule.

DISCUSSION

For many years all patients with nodular thyroids and thyrotoxicosis were said to be suffering from 'toxic adenomata' and were treated by the neat and technically satisfying operation of enucleo-resection, the 'adenomata' being shelled out of their capsules with a minimum of disturbance to the rest of the gland. The theory underlying this procedure was of course that the thyrotoxic symptoms were produced by the adenomata, as in the case of tumours of the parathyroid or the islet cells of the pancreas, whilst the remainder of the gland tissue remained normal. As time went on, however, it was found that in many cases, despite the initially excellent cosmetic result, the thyrotoxicosis persisted and even became more pronounced.

Consequently it became necessary to revise this conception and to study more closely the nature of the morbid anatomical and physiological changes which may occur.

Study of *Table I* above shows that a difference between the goitre with multiple nodules and the single nodule is manifested by their natural history. Of 63 nodular goitres, 31 (49 per cent) showed toxic symptoms and 4 (6 per cent) were found to be malignant. On the other hand, 59 single nodules included only 4 (7 per cent) which were associated with thyrotoxicosis, but 8 (13·5 per cent) which were malignant. Though the present paper is not primarily concerned with the malignant tendencies of the solitary nodule (the series, too, is small), these figures do emphasize that a high proportion of these solitary nodules are true neoplasms. This conclusion was also arrived at by Boyd (1938), who studied the pathology of these nodules and pointed out that they arose in young patients (usually between 20 and 30), in glands which were otherwise macroscopically normal, and that they did not recur after removal. Although there were two common forms, the colloid and the 'fœtal' adenoma, the many intermediate appearances showed that they probably arose in the same way; he considered that Wolfler's theory of embryonic remnants was probably incorrect and that these tumours arose by dedifferentiation from normal adult thyroid epithelium.

On the other hand, the nodular goitre is a diffuse process throughout the gland, consisting of patches of involution alternating with more hyperplastic areas and with no evidence of the well-marked encapsulation seen in the single nodule; removal of one nodule is followed by the reappearance of others in a short space of time.

Assessment of Secretory Activity.—When symptoms of thyrotoxicosis coexist with the presence of a solitary thyroid nodule, the surgeon must know the site of production of the thyroxin if the operation is to bring relief. Three sites have been suggested: (1) the nodules themselves; (2) the compressed gland tissue around the nodules; and (3) the uninvolved gland tissue.

Histological assessment is unreliable, as all gradations may be found in the single nodule from the 'fœtal' type of thyroid tissue to varieties closely resembling normal thyroid vesicles; but it is interesting to note that though the more undifferentiated types may suggest the possibility of malignancy, the usual staining methods do not give any reliable indication of the degree of secretory activity. For this, special Golgi stains are required.

Iodine Metabolism.—Fœtal and colloid nodules contain almost invariably less iodine than normal thyroid tissue, but until comparatively recently it has been difficult scientifically to assess the rate of thyroxin production. Experiments on feeding tadpoles with nodular tissue gave contradictory results.

Recently, Cope, Rawson, and McArthur (1947) have described a more accurate biological test which depends upon the degree to which a given quantity of thyrotropic hormone is inactivated by the thyroxin in tissue with which it is incubated. Its residual activity after treatment is assayed by injection into chicks, the effect on the thyroid vesicles of which being then observed.

The recent development of tracer substances has opened up a new field both for research and therapy. Radio-active iodine isotope (I^{131}) is one such material

which is being used in the U.S.A. for determining the metabolism of iodine in normal and abnormal glands. Very small doses are given by mouth from 12 to 24 hours before operation, the patient having been deprived of iodine for several days. The dose of from 25 to 100 microcuries of radio-iodine I^{131} is given by mouth with normal sodium iodide, and toxic effects have not been observed hitherto. The distribution of the radio-active isotope in the tissues can then be traced with a Geiger counter or estimated by direct analysis after excision. By laying a section of excised tissue on a photographic film an auto-radiograph can also be obtained, showing the areas which have taken up the radio-iodine.

It is found that with a normally functioning gland 40 per cent of the radio-iodine is absorbed by the thyroid and 60 per cent excreted in the urine within 36 hours. None has been recovered from the circulating blood. An overactive thyroid has a much greater affinity and may retain 80 per cent of ingested radio-active iodine, whilst a gland depressed by thiouracil may only retain 20 per cent.

Analysis of the various parts of the gland after resection shows interesting results, for in diffuse hyperplasia the iodine is fairly evenly distributed throughout the gland, but in toxic nodular goitre it is mostly concentrated in the posterior 'para-nodular' tissue, the actual nodules and cysts which usually lie anteriorly containing relatively small amounts. For this reason large proportions, such as seven-eighths, of the thyroid gland can be excised without producing gross hypothyroidism provided that the remaining gland tissue is sufficiently active.

Investigation of the iodine affinity of non-toxic single nodules gives varying results: as a rule they retain far less radio-active iodine than the remainder of the gland, where the concentration may be over twenty times as great.

The majority of single nodules therefore appear to be functionally inactive and 'adenomata' many times the size of the uninvolved thyroid tissue can be removed without causing myxœdema. Cases have in fact been recorded of myxœdema being actually relieved by the removal of a large adenoma which had presumably interfered with the function of the remainder of the gland.

There are, however, many gradations, and in a few instances a greater affinity for iodine is found in the nodule than in the rest of the gland; the concentration of radio-active iodine found may be 20 times or even 700 times as great (Cope, Rawson, and McArthur).

If the secretory activity is sufficiently high and the nodule sufficiently large the patient will evince clinical signs of thyrotoxicosis.

These rare patients may therefore truly be said to be suffering from a toxic adenoma, and may confidently be expected to obtain relief of their symptoms by excision of the nodule and by that alone.

Surgical Significance.—A surgeon operating for the relief of thyrotoxicosis must be able to distinguish between a true toxic adenoma and a toxic nodular goitre in which enucleo-resection is inadequate and a thorough subtotal thyroidectomy is required. The more important clinical feature is that at operation, in a patient with a true toxic adenoma, the uninvolved portion of the gland appears normal, or even atrophic as a result of the production by the overactive nodule of more than enough thyroxin to supply the needs of the body. After removal of the nodule, a temporary hypothyroidism may occur, but this disappears as the remainder of the gland becomes reactivated.

The atrophic tissue appears relatively pale and shrunken, in contrast to the adenoma, which is vascular and active-looking. Similar atrophic changes may be encountered following on heavy and prolonged dosage of thyroid by mouth.

When (as in *Case* 4) the surrounding tissue is not pale and atrophic, but contains cysts and nodules, the large nodule is probably not the cause of the thyrotoxicosis and a subtotal thyroidectomy should be performed as in any toxic nodular goitre.

CONCLUSIONS

1. Whereas in the majority of patients with toxic goitre the thyroid gland is abnormal throughout, a very small minority (4 per cent in our series) are found to have a single nodule as the only pathological abnormality.

2. This single nodule is distinct from the inactive involution nodules of nodular goitre and is recognized by the normal or even atrophic appearance of the remainder of the gland.

3. Because it is probably a true neoplasm, it can be correctly termed an 'adenoma', and because it is responsible for the thyrotoxicosis it is a true toxic adenoma.

4. Confirmation of its secretory overactivity can be obtained by testing samples of tissue for contained thyroxin by its power to inactivate thyrotropic hormone, or by measuring its affinity for radio-active iodine.

5. Whereas subtotal thyroidectomy is the correct treatment for diffuse and nodular toxic goitre, it may be excessive in dealing with a true toxic adenoma when the non-involved gland tissue is relatively inactive and temporary hypothyroidism might ensue. Removal of the nodule alone will suffice to bring lasting cure of the thyrotoxicosis.

6. Most single nodules are functionally inert and the cause of the oversecretion of thyroxin in this small minority remains largely unexplained.

I am indebted to Mr. Geoffrey Keynes and to Professor Paterson Ross for their advice and encouragement.

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POTT'S PUFFY TUMOUR*

By LAMBERT ROGERS, Cardiff

"... The part stricken generally swells, and becomes puffy and tender, but not painful; neither does the tumour rise to any considerable height, or spread to any great extent."—Percivall Pott, 1760.

Although Pott's puffy tumour is but rarely seen to-day, its significance as a sign of extradural abscess is widely known; it may be because, as Sir D'Arcy Power has suggested (1923), the alliteration has taken a firm hold of the surgical mind.

The following examples (*Figs.* 449, 450) occurred in boys aged 11 and 16 respectively. In the first the cranial osteomyelitis was metastatic from an old-standing osteomyelitis of the ilium; in the other the cranial bone infection followed a cold in the head and rhinorrhœa.

Case 1.—In April, 1935, a schoolboy, aged 11, who had been attending hospital since March, 1931, because of osteomyelitis of the left ilium, reported a painless swelling on his head (*Fig.* 449). He stated he had bruised his head at the site of the swelling some two months before it appeared.

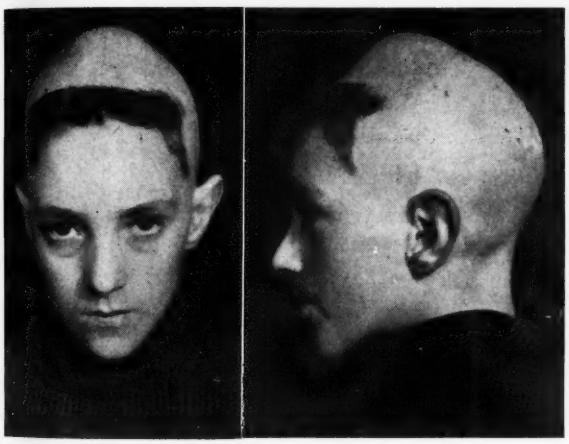

Fig. 449.—Pott's puffy tumour in a boy aged 11.

At operation (May 3, 1935) a transverse incision was made through the swelling and pus poured out; the pericranium was seen to have been stripped off the bone from which pus was exuding. A trephine disk was removed from this area and the dura mater exposed. It was seen to be covered with sprouting granulations upon which small beads of pus could be seen. The wound was closed after providing drainage. The pus yielded a profuse growth of *B. alkaligenes fæcalis*.

I operated upon this patient at the British Postgraduate Medical School (1935) and am indebted to the authorities for the subsequent history. He has had further operations since—in March, 1936, for an appendix abscess (Col. Harnett), and September, 1946, for a recurrence of the extradural abscess (Mr. Knight), when penicillin proved helpful.

Case 2.—A schoolboy, aged 16, had an acute attack of coryza with rhinorrhœa. Three weeks later he complained of headaches, followed later by vomiting and stiffness of the neck muscles. Lumbar puncture was performed and showed normal cerebrospinal fluid. He had slight pyrexia and a leucocytosis of 13,000. A fluctuant swelling formed over the vertex of the skull (*Fig.* 450). He had been given sulphonamides for a week, followed by penicillin, 50,000 units administered 3-hourly.

Fig. 450.—Pott's puffy tumour in a boy aged 16.

Aspiration of the swelling (July 20, 1948) yielded brown pus which remained sterile on culture.

At operation (July 21) a transverse incision was made through the swelling, and foul-smelling brown pus flowed out; the pericranium was found stripped from the bone, from which beads of yellow pus were seen to exude. A trephine disk was removed and between the inner table of the skull and the thickened and white dura mater, a collection of yellow pus was found and evacuated. The wound was closed and drainage provided by means of two small tubes led through stab openings in the frontal flap. Penicillin was used both locally and systemically. Convalescence was uninterrupted.

COMMENTARY

Asked what a Pott's puffy tumour is, the student usually replies that it is an œdematous area of the scalp related to an underlying extradural abscess. In the earliest stages of the condition this conception is probably correct, but by the time the swelling is really puffy it is due to more than œdema and its contents are mainly pus, as in the two instances here noted. Percivall Pott, in his masterly account of the condition given in 1760, in which he writes of a "puffy circumscribed, indolent tumour of the scalp", and a spontaneous separation of the pericranium from the skull as indicating an extradural abscess, described the contents of the swelling as "bloody ichor". His cases were all traumatic and he was endeavouring to distinguish intracranial suppuration from intracranial hæmorrhage. In the cases here reported the cranial osteomyelitis with which was associated the extradural abscess was in the one metastatic from an old bony lesion, and in the other followed sinusitis.

*Read before the Society of British Neurological Surgeons on Nov. 26, 1948.

These subepicranial abscesses well illustrate the remarkably impervious and beautifully protective barrier which the pachymeninx presents to the spread of infection within it. While what is at first a mere puffiness of the scalp may become a frank subpericranial abscess, spread inwards is unusual and intracerebral suppuration in these cases is apparently rare. Macewen (1893) refers to such a possibility, but in the only case he records of a Pott's puffy tumour (Case LXIV)—a man, aged 45, who had received a severe blow on the side of the head from the shaft of a cart—there is not only no mention of an intradural abscess but he states, "On incision the skull was found bare, a small quantity of semi-purulent exudation bathing the bone . . . Between the internal plate of the skull and the dura there was a considerable layer of freshly formed granulation tissue bathed in purulent exudation. His symptoms quickly disappeared after operation."

SUMMARY

Two cases of Pott's puffy tumour are illustrated. In each the tumour contained pus associated with an underlying separation of the pericranium, a localized cranial osteomyelitis, and an extradural abscess. The protective character of the dura is emphasized and the rarity of intradural complications. Treatment consists in removal of the infected bone, drainage, and chemotherapy.

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FOAM-CELL GRANULOMA IN CHRONIC PYONEPHROSIS SIMULATING TUBERCULOSIS

BY H. J. BARRIE

FROM THE DEPARTMENT OF PATHOLOGY, TORONTO UNIVERSITY

FOAM cells are commonly found in the kidney in chronic renal infections and may form aggregates visible to the naked eye. In the two cases to be described these aggregates dominated the picture and, owing to their resemblance to caseous material, initially caused a wrong diagnosis of renal tuberculosis. I have been unable to find similar cases discussed in the literature, but this is due more to general neglect of the histological changes in chronic renal infections than to the rarity of the condition. Schlagenhaufer (1916) used the names *Pseudozanthomzellen* or *Staphylomykosen* to describe five cases of renal and perirenal staphylococcal infection in which the predominating feature was the presence of foam cells containing doubly refractive lipoid, but his illustrations make it clear that he was describing what is now usually called a carbuncle of the kidney. Putschar (1934) described the vascular granulation tissue of pyonephrosis as sometimes being so rich in foam cells that it looked butter-yellow, and for this appearance unfortunately borrowed the names which were coined by Schlagenhaufer.

CASE REPORTS

Case 1.—A man, aged 62 years, complained of severe pain in the right lumbar region radiating to the front of the body. An ascending pyelogram showed dilatation of the pelvis and calices of the right kidney, but no dilatation of the ureter.

On exposure of the kidney it was found to be adherent to the renal bed and the suprarenal by what appeared to be tuberculous granulation tissue containing areas of caseation.

The kidney measured 5 × 5 × 4 cm. (*Fig.* 451). The capsule was covered by adherent fibro-fatty tissue and was firmly adherent to the kidney substance, especially around several small, firm, yellow masses which

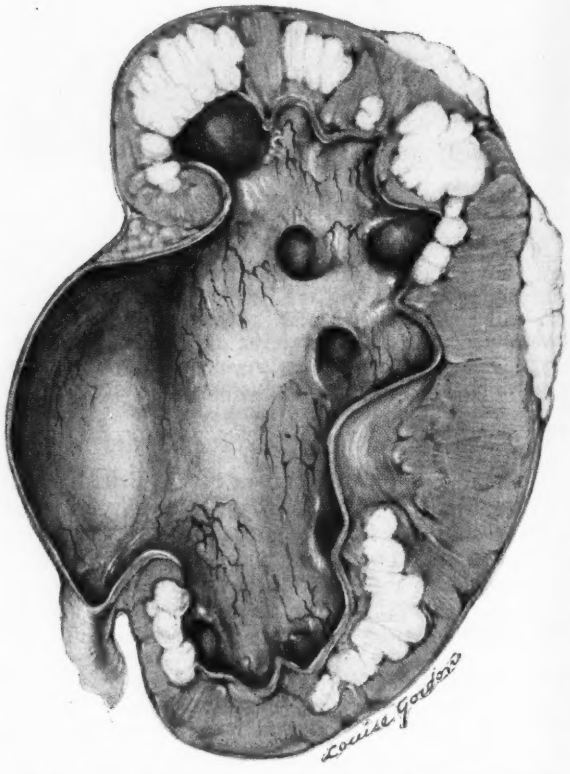

FIG. 451.—Foam-cell aggregates in medulla and under capsule of kidney.

lay just outside the kidney. The largest of these masses formed a dome 1·5 cm. in diameter and 0·5 cm. thick, and its summit was ragged where it had been torn from the renal bed. The renal cortex was pale and evenly narrow and the line of junction with the medulla was indistinct. The apical halves of the pyramids were almost replaced by sharply-defined yellow nodules, which had ragged, fissured borders where they were bulging into the dilated calices. The pelvis was dilated, and its thickened wall had an inner red, shaggy lining and an outer, grey lamina 0·2 cm. thick. The renal sinus was filled by rather gelatinous lemon-yellow, fat-rich connective tissue.

MICROSCOPICAL EXAMINATION.—In the cortex no convoluted tubules were recognizable. The crowded glomeruli were separated by very small shrunken empty tubules, lined by cuboidal cells with big dark nuclei and hydropic cytoplasm. Increase of connective tissue was slight, being more marked directly under the capsule. Some of the collecting tubules were dilated and contained cellular casts. Lymphocytes were scanty in the outer part of the cortex, but, together with polymorphs, became abundant towards the cortico-medullary junction. Glomerular changes were relatively slight and consisted of even thickening of the basement membranes of the capsules and separation and shrinkage of the tufts. The arterioles showed moderate widespread cellular thickening of the intima. The connective tissue of the peripheral part of the pyramids was swollen, pink, and hyaline. The nodules, which macroscopically appeared yellow, were composed of aggregates of large foam cells between which was a compressed network of capillaries. In frozen sections stained with Sudan III, the foam cells were full of bright-red droplets. Unstained frozen sections, viewed with crossed Nicol prisms, showed abundant anisotropic material, the brightest consisting

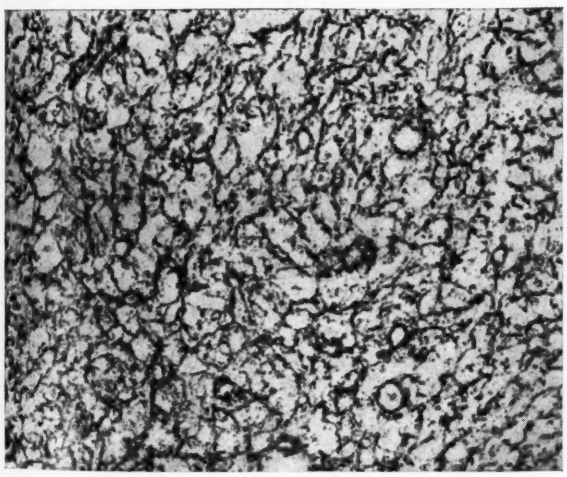

FIG. 452.—*Case* 1. Section of nodule. Reticulin stain. (× 246.)

of small splinter-like crystals. The fibrocytes in the tissue surrounding the foam cells contained abundant minute droplets of fat. Sections stained by Foot's modification of Perdran's silver method (*Fig.* 452), showed that the foam cells were closely invested by a dense web of interlacing reticulin fibres. The surrounding connective tissue was slightly compressed, but there was no increase of collagen. Sections treated with potassium ferrocyanide and HCl showed no blue coloration in or around the foam cells. In the papillæ the foam cells were more sparse and, together with numerous polymorphs and patchy aggregates of red cells, lay in the interstices of an exceedingly vascular granulation tissue in which remained a few disorganized collecting tubules.

In places the epithelium of the pelvis had undergone metaplasia to a primitive squamous form and elsewhere had desquamated, exposing heavily infiltrated vascular granulation tissue which was continuous with that of the papillæ, but which contained no foam cells. The yellow nodules in the capsule of the kidney were composed of groups of foam cells, scattered polymorphs and lymphocytes, patchy collections of extravasated blood, and a rich interlacing tangle of fibroblasts and capillaries.

Case 2.—A male A.R.P. orderly, aged 46 years, attended hospital in March 1942, with a history of

FIG. 453.—*Case* 2. Foam cells in nodule. H. & E. stain. (× 555.)

pain on micturition for three months; a small stone was then removed from his bladder. He was admitted again in October, 1942, complaining of attacks of severe

FIG. 454.—Transformation of fibroblasts into foam cells in renal suppuration.

pain in the left loin, of sudden onset and lasting from one to four hours. At cystoscopy, the left ureter was seen to exude pus, and the mucosa surrounding it was œdematous and swollen. The urine was alkaline and

contained a trace of albumin and slight excess of pus cells, and culture of it produced a heavy mixed growth of *Bacillus coli* and *Bacillus pyocyaneus*. Excretion pyelography showed a large non-functioning left kidney. The left kidney and 7 cm. of attached ureter were removed. The pelvis was considerably dilated and full of turbid fluid. Its lining was mottled red and greyish-brown, and its wall was thick and œdematous. The ureter was thickened and dilated. The outer surface of the kidney was fairly smooth, but the capsule was firmly adherent, and when the latter was stripped it took with it small pieces of kidney parenchyma. There was blurring of the kidney pattern and shallow ulceration of each papilla. These ulcers were bordered by clusters of firm, bright-yellow, semi-confluent nodules each about 0·4 cm. in diameter and the kidney was thought to be tuberculous.

MICROSCOPICAL EXAMINATION.—The inflammatory changes in this kidney were of longer standing than those in *Case* 1. There was gross ischæmic destruction of most of the glomeruli, which were represented by small homogeneous masses compressed by hyalinized capsular thickening. In the cortex interstitial fibrosis and lymphoid infiltration were considerable. The primary branches of the renal arteries, and the arcuate arteries, were almost obliterated by hyperplasia of the intima, and the walls of the arterioles had undergone hyaline degeneration.

The yellow masses in the pyramids contained foam cells similar to those in *Case* 1, but here there were more fibrocytes intermixed with them (*Fig.* 453). The papillæ were heavily infiltrated with polymorphs, red cells, and foam cells and contained disorganized tubules as in *Case* 1. The pelvis was lined by irregular transitional and primitive squamous epithelium and was only slightly infiltrated by lymphocytes.

DISCUSSION

In these two recorded cases of pyonephrosis it was not the presence of, but the great number of, foam cells that was remarkable. Consideration of their origin is of some interest. Almost every type of pathological change in the kidney may result in the appearance of foam cells there. In this, the kidney resembles the brain, and both these organs have a high lipoid content and a poor fibrous reaction to tissue damage.

Poor fibrous reaction leads to poor localization of inflammation, to prolonged polymorph and lymphocyte infiltration, and to prolonged cell breakdown, and is, therefore, favourable to the accumulation of fat- and lipoid-laden foam cells. The extracapsular lipoid deposits in *Case* 1 might have accumulated along the course of the lymphatics which follow the perforating arteries and anastomose with the perirenal vessels. Superficially, therefore, it is easy to explain the presence of foam cells in chronic inflammation of the kidney.

The reason for the occurrence of such large aggregates in the pyramids, however, is not so simple, for one might have thought they would be found in the cortex, where the lipoid content of the kidney is highest, rather than in the relatively acellular pyramids.

On theoretical grounds, the accumulations of fat and lipoid might have been either derived from local lesions, such as prolonged suppuration, or deposited in the medulla by lymphatic and tubule drainage of breaking-down convoluted tubules, much as a moraine is deposited by a glacier. Many kidneys in every stage of acute pyogenic inflammation were examined for evidence on these points. None was found to support the theory of a moraine. In pyogenic infections the cortical tubules disappear with the formation of very little stainable free fat or lipoid, and very little fat seems to drain down the collecting tubules. Among the kidneys affected by pyelonephritis, there were several containing microscopical aggregates of foam cells in the cortex and even more showing similar small aggregates in the medulla. Study of their size, shape, and stages of formation suggested that the most important single factor in their genesis was suppuration. In pyelonephritis, foci of suppuration are common in both medulla and cortex and the greater size and frequency of foam-cell aggregates in the medulla had obviously a further contributing cause. This was found in the source of the foam cells. In foci of suppuration in the kidney it was very difficult to find blood monocytes. When the polymorphs disintegrated, the fatty products were often taken directly into the cytoplasm of the fibroblasts. This process is well illustrated in *Fig.* 454, in which every stage of foam-cell formation can be easily recognized.

This formation of the foam cells from fibroblasts explains the surprisingly dense network of reticulin that traverses the aggregates of foam cells. The connective tissue of the renal medulla with its finely textured collagen is of a highly individual type and does not readily produce fibrous scars. Thus, when fibrous scarring is found in chronic pyelonephritis, it is usually limited to a band under the submucosa of the pelvis and to a band in the outer part of the medulla derived from the fibroblasts in the adventitia of the arcuate vessels. The relative inertness of the medullary connective tissue and the tendency that it shows to form foam cells instead of scar tissue are possibly of great importance in avoiding obstruction of the connecting tubules. A further possible contributing cause of the big medullary foam-cell aggregates is the frequency of small medullary infarcts in pyelonephritis.

With regard to the naked-eye similarity to tuberculosis in these two cases, one differentiating factor was the absence of outlying clusters of grey tubercles, which are usual when tuberculosis has reached the stage of caseation. The other, and more important, is that caseous material tends to break away and leave cavities when it reaches the surface of a pyramid.

In the microscopical sections the difference was apparent at a glance in *Case* 1, for instead of homogeneous, pink, caseous material, there was the blue-grey of the foam cells. In *Case* 2 the foam cells were intermixed with fibroblasts and formed little follicles surrounded by lymphocytes that had some resemblance to a formative type of tuberculosis.

SUMMARY

1. Two cases of pyonephrosis are described which were remarkable for foam-cell aggregates in the renal pyramids.

2. These cells were believed to be derived from fibroblasts in the medulla at the site of small areas of suppuration.

3. This behaviour of fibroblasts is probably of importance in the avoidance of scarring of the medulla.

I would like to thank Mr. Ferguson Wilson and Mr. Blacow Yates of the Royal Hospital, Sheffield, for permission to publish the clinical details of these cases. The histological material was sectioned by Mr. D. Bradey, the photographs were taken by Miss J. G. Brown, and the paintings made by Mrs. L. Gordon.

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LOCALIZED DIVERTICULITIS IN THE TRANSVERSE COLON

BY H. E. LOCKHART-MUMMERY, LONDON

THE following case appears to be sufficiently unusual to merit description.

CASE REPORT

HISTORY.—Mrs. F., aged 48, was admitted to Westminster Hospital at 4 p.m. on July 3, 1947. For the previous ten years she had attended her doctor at intervals complaining of headaches and fatigue, but had never had any abdominal symptoms and had always regarded herself as very healthy. She had one son, aged 18, and in July, 1944, had had a hysterectomy for fibroids, with a smooth convalescence. As long as she could remember she had had difficulty with the bowels, and had formerly taken regular doses of paraffin and phenolphthalein, omission of the regular dose resulting in hard stools. But since the hysterectomy her bowels had been normal, and she had not needed any aperient regularly.

Three days before admission she had a feeling of generalized abdominal distension which persisted unchanged all that day and the next. Forty-eight hours before admission a mild aching pain developed in the right iliac fossa; but she carried on with her household duties, and slept well that night. The pain continued rather worse all through the next day and made walking difficult, but again she was able to sleep well. On the day of admission the pain was very severe, still in the same place, and she came to hospital and was admitted. During those three days she had lost her appetite and had some nausea, but had not vomited. There had been no urinary symptoms, and the bowels had acted normally every day without aperients.

She denied any previous attacks of abdominal pain, and was emphatic that at no time in this attack had there been any generalized abdominal pain—merely the feeling of abdominal distension.

ON EXAMINATION.—Temperature 99·2°, pulse 88, respiration 20. A little furring of the tongue. General condition good; heart, lungs, and C.N.S. showed no abnormality. There was a midline subumbilical scar well healed, and in the right iliac fossa, just above and medial to McBurney's point, was an area of tenderness with some overlying rigidity. There was no hyperæsthesia, but the release sign was positive.

Rectal examination showed no tenderness or other abnormality.

A fairly confident diagnosis of acute appendicitis was made.

AT OPERATION.—Performed under general anæsthesia at 6 p.m. There was a suggestion of a mass in the right iliac fossa on palpation of the abdomen under anæsthesia, but nothing definite.

The abdomen was opened by a right paramedian incision. There was a little free fluid in the peritoneal cavity. Immediately, the transverse colon presented in the wound, and a tumour the size of a small hen's egg was felt in it about 6 in. from the hepatic flexure. The appendix was examined and found to be normal and the great omentum was found to be adherent to the scar of the previous hysterectomy. The incision was enlarged sufficiently to allow a hand to enter the abdomen, the omentum freed from the old scar, and the lump in the colon was then carefully examined. It was hard and homogeneous, with no obvious signs of inflammation, and no old or recent adhesions, and through the bowel wall a central depression could be felt. It was considered that the mass was most probably a carcinoma and that a resection by the Paul-Mikulicz method would be the wisest course. The hepatic flexure was mobilized, and after 'double-barrelling' the bowel, the abdomen was closed around the exteriorized loop, which was then removed. A Paul's tube was tied in the proximal end, and a clamp left on the distal end for 48 hours.

PROGRESS.—The patient made a good recovery from the operation and an enterotome was applied to the spur on the sixth day, and became loose on the eleventh.

FIG. 455.—Mucosal aspect of specimen. Note orifice of diverticulum.

On the eighteenth day there were symptoms, signs, and X-ray appearances of pulmonary infarction, and a five-day course of heparin was given, with no further evidence of thrombo-embolic disease. She was discharged soon after to convalescence, and was readmitted in October for closure of the colostomy. This was performed extraperitoneally, and her convalescence was uneventful. When last seen in out-patients she had remained well and bowel function was normal.

THE SPECIMEN.—The specimen consisted of 6 in. of transverse colon. On the mesenteric border there was a small diverticulum 2 cm. in depth, with a very narrow opening 3 mm. wide (*Fig.* 455). There was much thickening and œdema around the diverticulum, making a visible and palpable mass in the bowel wall.

Microscopically, the cavity of the diverticulum was seen to be filled with mucus and debris. The mucosa

is seen passing through the muscle coat, but farther out is ulcerated and desquamated by an acute inflammatory reaction, which can be seen spreading into the surrounding œdematous connective tissues. The circular muscle is completely interrupted where the diverticulum passes through and this is very well seen in the photomicrograph (*Fig.* 456). A thin layer of muscle, apparently

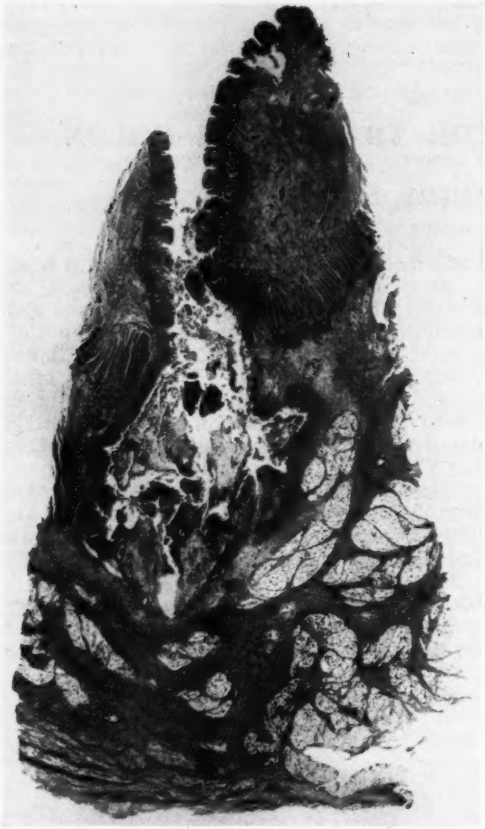

FIG. 456.—Photomicrograph of specimen. Note gap in circular muscle.

continuous with the longitudinal muscle coat, is continued over the diverticulum and can just be traced when the high power is used, but is destroyed in places. Nevertheless, the gap in the circular muscle is so definite that I have little doubt that this is an 'acquired' diverticulum (*see below*).

The bowel wall and mucosa around the mouth of the diverticulum is normal, and there is no evidence of malignancy in any part.

SUBSEQUENT X-RAY EXAMINATION.—Both barium meal and barium enema examinations were performed on this patient before her final discharge from hospital. There was a large solitary diverticulum apparently arising from the convex border of the duodenum at the junction of the second and third parts (*Fig.* 457). No other diverticula were seen in the small bowel. The appendix was large and wide-mouthed, and a few scattered diverticula were seen in the cæcum and ascending colon, best seen in the 24-hour film (*Fig.* 458). Barium enema examination some days later showed one small diverticulum in the descending colon also, but the proximal diverticula were not visualized on the enema.

COMMENT

Localized diverticulitis in other parts of the colon than the sigmoid is comparatively rare. Most of the reported cases have occurred in the cæcum and adjacent part of the ascending colon, and Anderson (1946) was able to find over 90 such cases in the literature. Usually, these cases have been reported as 'solitary diverticulitis', though in many cases

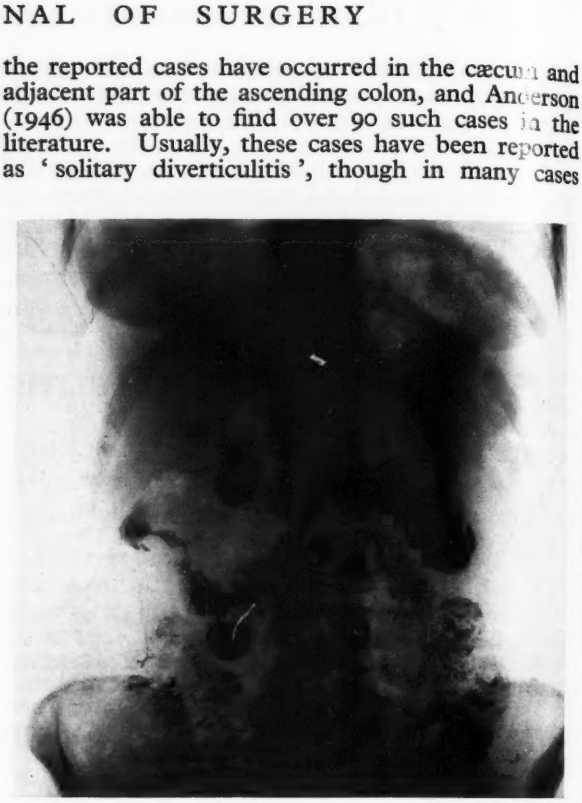

FIG. 457.—Barium meal, showing duodenal diverticulum.

there has been insufficient radiological examination to support such a diagnosis. From a pathological point of view it seems to be generally accepted now that intestinal diverticula may be either (1) congenital, when all the coats of the bowel are present in the

FIG. 458.—24-hour barium meal, showing cæcal diverticula.

diverticulum, or (2) acquired, when there is a gap in the circular muscle of the bowel and only mucosa and muscularis mucosæ are present in the diverticulum. Both types have been reported in the cæcum, and this part of the bowel appears to be

the commonest site of congenital diverticula and their close relations, enterogenous cysts (Evans, 1929).

In the transverse colon, however, diverticulitis appears to be rare. Dixon, Deutermann, and Weber (1938) give the incidence of diverticula in the transverse colon as 3 per cent (of all intestinal diverticula), and then they are usually associated with extensive diverticulosis of the distal colon. I have only been able to find one case in the literature of an isolated diverticulitis in the transverse colon. That case, reported by Thompson and Fox (1944), was very similar to the one here reported. Their patient was a man aged 35, who was diagnosed pre-operatively as perforation of a peptic ulcer. Laparotomy was performed, and he was found to have peritonitis from perforation of a mass in the transverse colon, which was thought to be a carcinoma. Resection by the Paul-Mikulicz method was done, and he made a good recovery. Microscopical examination of the specimen showed a defect in the muscle wall of the bowel (i.e., an 'acquired' diverticulum), and subsequent X-ray examination revealed no other diverticula in the gastro-intestinal tract. This case, then, appears to be a real 'solitary diverticulitis', unlike the one here reported, in which other diverticula were present in the colon, as well as one in the duodenum.

The association of duodenal and colonic diverticula is not uncommon, and Edwards (1939) states that in approximately 25 per cent of cases examined by him this association existed. It is interesting, however, particularly with regard to the pathogenesis of acquired diverticula. If, as contended by Edwards and other writers, they are due to irregular spasm of the bowel muscle maintained for some time, then it suggests that such spasm may exist throughout the whole bowel. Diverticula are, presumably, most common in the sigmoid colon because of the solidity of the contents, the more powerful muscle, and more violent muscular action in this part of the bowel. In the same way inflammation in diverticula of parts of the bowel where the contents are fluid is uncommon, the commonest being diverticulitis of the cæcum. Cases of diverticulitis in the small bowel and in the duodenum have been reported, and are quoted by Edwards, but appear to be of extreme rarity.

As Fairbank and Rob (1947) point out in a recent paper, it is difficult to see any single point of difference in the clinical picture between acute diverticulitis in the proximal colon and acute appendicitis. In both central abdominal pain may occur, and in this connexion it is of interest that the patient reported here complained of a generalized feeling of abdominal distension prior to the onset of pain in the right iliac fossa, though she denied any central abdominal pain. From a study of the cases quoted from the literature by Bennett-Jones (1937), it seems that this central pain may occur whether or not there is a muscular wall to the diverticulum, and its cause is still not fully understood, though it appears to be a visceral pain.

As in most reported cases, the case here presented was diagnosed pre-operatively as appendicitis and at laparotomy as carcinoma, but it is heartening to know that one is in good company when one makes mistakes! However, over 90 cases have been reported; and therefore, though rare, it is a possibility which should come to the mind of a surgeon when confronted with an inflammatory lesion in the proximal colon not arising from the appendix. Suspicion of carcinoma will often lead him to perform resection, which, though probably the right treatment in the transverse colon, is not always necessary in the cæcum. Nevertheless, mistakes will be fewer if the condition is kept in mind.

I wish to express my thanks to Dr. George Lumb for the pathological report, and to Dr. Peter Hansell for the photographs; and particularly to Sir Stanford Cade and Mr. E. Stanley Lee, under whose care this patient was admitted, for permission to publish this report, and for help and encouragement in its preparation.

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A CASE OF THYMOLIPOMA

WITH OBSERVATIONS ON A POSSIBLE RELATIONSHIP TO INTRATHORACIC LIPOMATA

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IN view of the interest in recent years in the surgical treatment of myasthenia gravis by removal of thymic tissue or of a definite thymic tumour, the pathology of all tumours of the thymus assumes considerable importance. Many of these growths are not associated with myasthenia gravis. Some may present only with the symptoms of a space-containing thoracic lesion and some may be completely silent. This paper concerns a single case belonging to the latter group, being a benign tumour composed of fatty and thymic elements resembling only one other tumour recorded in the literature. It is hoped to show that this tumour is a definite entity deserving the name of thymolipoma, and to suggest that other examples may possibly have been recorded as cases of intrathoracic lipomata.

CASE REPORT

HISTORY.—A labourer, aged 47, who had enjoyed good health all his life, was accidentally struck on the head by the handle of a winch during the course of his work. The blow was a severe one and he died within a few hours. It was confirmed at the Coroner's inquest that the man had never complained of any form of illness.

Post-mortem Findings.—The vault and base of the skull were severely smashed, with extensive laceration of the brain and herniation of intracranial contents. There were no other injuries.

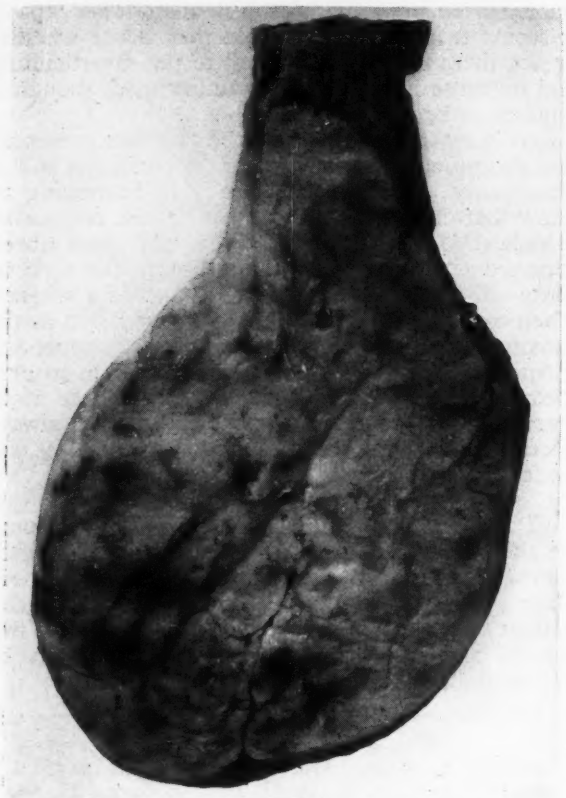

FIG. 459.—The gross specimen showing the cut surface. Most of the tumour is composed of fat, scattered throughout which are numerous small areas of thymic tissue, which appear dark in the photograph.

In the thorax was an unexpected finding. There was an enormous pedunculated tumour arising from the anterior mediastinum and lying almost entirely in the right pleural cavity in relation chiefly to the diaphragm and the anterior chest wall. The right lung was displaced upwards but there were no adhesions or free fluid in the pleural cavity. In shape the tumour resembled a flattened pear, measuring 22 × 16 × 6 cm., and weighing about 1100 g. (The weight is approximate only, as an allowance was made for a few small attachments which were left intact for museum purposes.)

The mass was completely enclosed in a moderately thin fibrous capsule covered by pleura, which became continuous above and medially with the parietal pericardium over the right side of the heart and to the tissue of the anterior mediastinum below the bifurcation of the trachea. The tumour floated in water and its general appearance suggested that it was a lipoma.

The cut surface of the tumour was yellowish in colour and fatty in appearance, with a number of thin septa dividing it up into indefinite lobules. Scattered throughout the fatty matrix were numerous small irregularly shaped, pinkish-white areas which were firm and rather gritty (*Fig.* 459). A diagnosis of intrathoracic lipoma would have gone unchallenged if it had not been for the microscopical appearances of these denser areas.

The heart was normal in size, although slightly displaced to the left. All the other organs showed no naked-eye abnormality.

HISTOLOGY.—The numerous small firm areas proved to be thymic tissue, and when added together amounted to a considerable quantity which it is estimated would be not less than a tenth of the whole tumour. In all, ten such areas were examined, all except one of which presented an identical histological appearance. The exceptional area will be described separately. The main mass of the tumour was composed of normal adipose tissue.

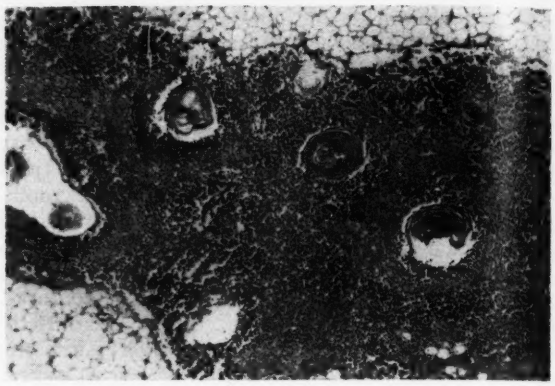

FIG. 460.—A low-power view of one of the thymic areas, surrounded by adipose tissue. Several Hassall's corpuscles are seen. (H. & E.) (× 37·5.)

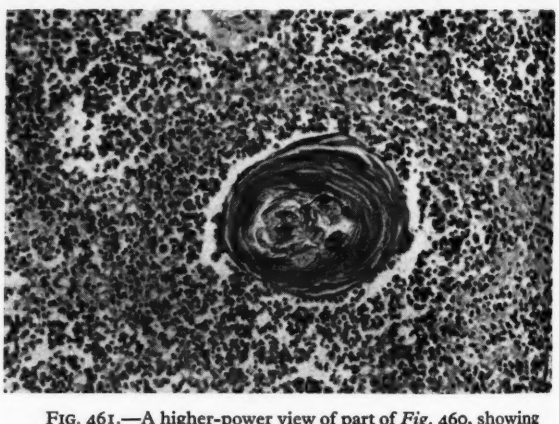

FIG. 461.—A higher-power view of part of *Fig.* 460, showing one of the Hassall's corpuscles with its central core of calcification. The surrounding cells consist mostly of lymphocytes ('thymocytes'). (H. & E.) (× 90.)

The majority of the thymic areas were composed of lymphocytes ('thymocytes'), with scanty diffusely scattered reticulum cells and fairly numerous Hassall's corpuscles (*Figs.* 460, 461). Many of the latter were large and practically all were acellular, with central calcification. There was no differentiation into cortex and medulla. The appearances of these areas thus fairly closely correspond to that of normal thymus. This picture, as has been stated, was identical in nine of such areas taken from widely separated parts of the tumour.

The tenth area, which showed a different histological picture, came from a rounded nodule measuring approximately 1 cm. in diameter with a well-defined edge. It thus differed somewhat macroscopically from the other

thymic areas, which had an irregular outline. No similar nodule was found in the half of the tumour through which numerous slices were taken. (The other half was preserved intact as a museum specimen.)

Histologically this nodule was partially encapsulated by a very thin layer of fibrous tissue and composed of solid nests and columns of cells set in a scanty loose fibrous stroma (*Figs.* 462, 463). The cells were essentially of the thymic reticulum type, although more clearly

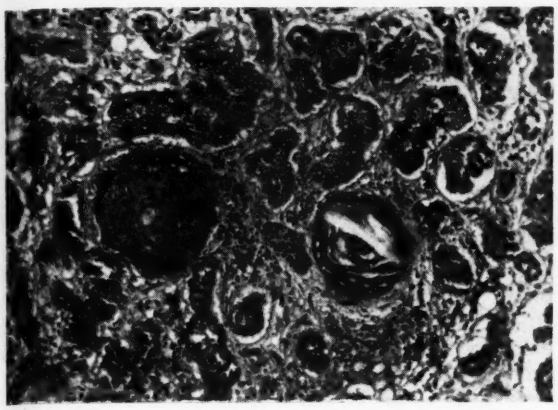

FIG. 462.—The adenomatous area, showing two Hassall's corpuscles, one of which is entirely cellular. (H. & E.) (× 75.)

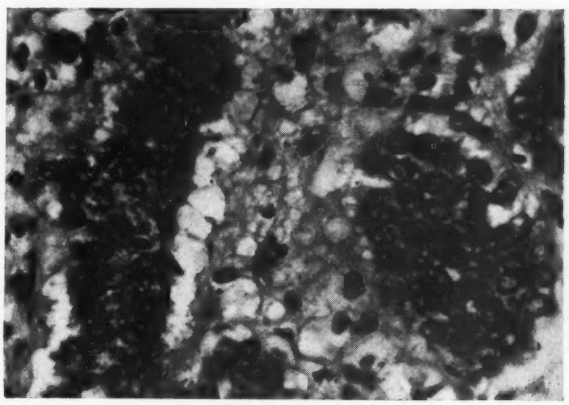

FIG. 463.—A higher-power view of part of the adenomatous area. The cells are of the reticulum type. The surrounding stroma contains a few lymphocytes. (H. & E.) (× 337·5.)

epithelial in nature than the reticulum cells of the normal thymus. The cytoplasm was scanty, rather foamy, and faintly acidophilic. The cell outlines were very indefinite, so that the appearance was almost that of a syncytium. The nuclei were round or oval, their diameters ranging from 3·5 to 10·5 μ, although the majority measured approximately 7 μ. The chromatin was scanty and in many of the nuclei chiefly outlined the periphery. A single nucleolus was seen very occasionally, but no mitoses were observed. Several small Hassall's corpuscles were present, one or two of which were completely cellular, while the rest had a central structureless mass surrounded by concentrically arranged flattened cells. The stroma contained scanty lymphocytes, and a very occasional lymphocyte was incorporated amongst the reticulum cells. The general appearance of this nodule, therefore, suggests that it is an adenoma of thymic reticulum cells.

DISCUSSION

Only one example of an essentially similar tumour has been found in the literature. The case is reported by Andrus and Foot (1937), who described a large thymic tumour in a boy aged 13 which was successfully removed. The tumour was about twice the size of the one here recorded and weighed 2235 g. Its gross appearance resembled a lipoma in which were scattered small yellowish-white areas. Histologically these areas were mostly very similar to those described above, except that the reticulum cells tended to take up a peripheral position. A very few areas "were composed entirely of small cells resembling lymphocytes and actively growing, as indicated by the many mitoses present. This was the only indication of malignant change in the growth, and it constituted but an infinitesimal part of the tumour." Thus broadly speaking this tumour closely resembles the one here described in being a large adipose mass containing small areas of thymic tissue.

The thymic nature of parts of both these large tumours cannot be disputed, although the relationship of the fatty stroma is not quite clear. Two possibilities present themselves: one is that the mass of adipose tissue represents a true tumour of fat associated with a multiplication of thymic tissue. In this case the growth would be of a mixed type, a thymolipoma, as the thymus is essentially entodermal in origin and fat is mesodermal. The alternative possibility is that the growth was primarily a large simple tumour of the thymus most of which has degenerated and been replaced by fat. One might argue in favour of the latter that the thymus in the course of its normal involution in adult life is replaced by fat. Murray and McDonald (1945) studied 100 thymuses from patients aged 4 months to 86 years, and found that adipose connective tissue increases with progressive age, whereas thymic tissue decreases. But in these tumours thymic tissue has certainly not decreased but has clearly increased in amount, and there are none of the histological features which one associates with involution—namely, gradual loss of the lymphocytes, followed by the reticulum cells, the Hassall's corpuscles surviving the longest.

It seems extremely unlikely that these two enormous tumours could have undergone an extensive fatty replacement in such an even manner. One cannot think of an example of any tumour in which a degenerative replacement process results in the original tissue being left in scattered areas of approximately the same size. The faint but definite lobulation of this tumour (it was much more marked in Andrus and Foot's case) also suggests that the lobules of fat are part of the original tumour and not a replacement phenomenon. Finally if this tumour has undergone a fatty replacement one cannot avoid the conclusion that this whole growth was at one time composed of an enormous mass of thymic tissue. This suggestion seems extremely unlikely in view of the fact that no pure benign thymomata of anything approaching this size have been described. Thus Norris (1936), who tabulated all the lesions of the thymus associated with myasthenia gravis which were reported between the years 1901 and 1935, recorded no tumour exceeding 60 g. in weight.

Andrus and Foot in their paper do not discuss the nature and origin of the fatty part of the tumour, and were content to call their example a "non-malignant thymoma". However, Foot (1947) agrees that a term indicating both its thymic and fatty nature would describe it better. One hesitates to complicate the terminology of tumours of the thymus any further, but as this growth appears to be a definite entity the term 'thymolipoma' is suggested.

Many of the papers on the subject of tumours of the thymus are concerned primarily in considering their relationship to myasthenia gravis, of which there is ample evidence in some cases. Norris (1936) assesses the incidence of thymic lesions in this disease at 50 per cent. In view of the large amount of thymic tissue in this thymolipoma it might therefore seem surprising that the patient, as far as can be ascertained, was in perfectly good health and had none of the symptoms of myasthenia gravis. Similarly, Andrus and Foot's patient had symptoms that could be accounted for entirely by those of a space-containing tumour.

A considerable number of tumours of the thymus have been recorded in which symptoms of myasthenia gravis are lacking, and there would appear to be no specific histological lesion present in tumours or enlarged thymuses associated with myasthenia gravis which is absent in tumours unassociated with this disease.

A note must be added on the histological appearance of the nodule, which has been diagnosed as an adenoma of thymic reticulum. The histology of this nodule resembles fairly closely that of a tumour of the thymus (Case 1) described by Margolis (1931.) The tumour tissue was disposed in similar nests and columns in an abundant stroma of fibrous tissue; the nuclei were similar, although some were pyknotic; and poorly-formed Hassall's corpuscles were present. Although the non-committal diagnosis of thymoma is made, Margolis in his discussion suggests that the tumour bears a close morphological resemblance to a carcinoma, arising probably from the reticulum. I would not, however, consider that the growth as described passes any of the usual criteria of malignancy, and that it could also be classed as an adenoma of thymic reticulum.

A Possible Relationship to Intrathoracic Lipomata.—In describing the growth it has been stressed that a diagnosis of intrathoracic lipoma was anticipated. Andrus and Foot anticipated a similar diagnosis in their case and were equally surprised when the scattered firmer areas revealed themselves histologically to be thymic tissue. Pure intrathoracic lipomata have been described in the literature on a number of occasions. McCorkle and his colleagues (1940) found 34 cases in the literature from 1783 to 1939. It is my intention to suggest that some of these lipomata may be in fact thymolipomata in which the thymic elements are even less obvious than in these two definite examples.

If one excludes a very occasional case, all the reported intrathoracic lipomata take their origin from, or have an attachment with, the mediastinal tissues in the area in which normal thymus or its remnants would be present. Some of the examples reported are stated to be lipomata on the evidence of naked-eye appearances only. Others have been submitted to only a cursory histological examination.

It is not unlikely, therefore, that unless a careful investigation is made, very small and sparse areas of thymic tissue could easily be overlooked, and the tumour would then be recorded as a pure lipoma.

One would not dispute the fact that ordinary lipomata are ubiquitous and therefore liable to arise in the mediastinum as much as elsewhere in the body. It cannot, on the other hand, be denied on the evidence here submitted that there also exist mediastinal tumours composed of thymic and adipose tissue together. Of the cases reported as lipomata I have only been able to find one in which the possibility of associated thymic elements has been considered. This case was reported by Beatson (1899) and is reviewed by other authors (McCorkle, Koerth, and Donaldson, 1940; Heuer, 1933). The suggestion that the lipomatous tumour which presented in the neck "might possibly contain elements connected with the thymus gland" is in fact a remark made in a society discussion before there had been any microscopical examination. The histology was not subsequently reported. Consequently, this case cannot be used to assist the argument for or against.

It is, therefore, suggested that very special attention should be paid in the future to the histological examination of any intrathoracic tumour having a resemblance to a lipoma. It may transpire that the thymolipoma is not quite as rare as the number of recorded cases suggests.

SUMMARY

A description is given of the pathological features of a tumour of the thymus weighing 1100 g. found incidentally at the post-mortem examination of a man aged 47 killed in an accident.

The only other similar tumour recorded in the literature is reviewed.

The nature of the growth is discussed and 'thymolipoma' is suggested as the most suitable name.

The possibility that other thymolipomata may have been recorded as examples of intrathoracic lipomata is considered.

My thanks are due to Professor H. A. Magnus for much helpful criticism and advice; to Dr. A. B. Bratton for his interest; and to Dr. A. Gilpin, who performed the post-mortem examination. I am indebted to Mr. W. Smith for the photographs.

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SHORT NOTES OF RARE OR OBSCURE CASES

TWO CASES OF PERSISTENT JEJUNITIS FOLLOWING PARTIAL GASTRECTOMY

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In the course of some 240 partial gastrectomies, I have encountered 2 cases where post-operatively the patients appear to suffer from a chronic inflammation of the upper jejunum. The symptoms of which both complain are persistent diarrhœa and rather vague tenderness down the left side of the abdomen. The 'diarrhœa' takes the form of a rather loose bowel movement after nearly every meal, and is checked only by repeated small doses of bismuth and opium, sulphasuxidine, even in large doses, having no effect. The pain in the left side is not severe and is diffusely distributed. It corresponds in position to the first 20 cm. or so of the jejunum below the gastric stoma as seen on barium meal screening, there being no demonstrable ulcer or special point of tenderness. In neither case have pathogens been found in the stool. Both patients are otherwise improved by their operation, have maintained their original weight, and have been able to continue with their previous work. However, both require a maintenance dose of bismuth and opium to reduce their frequent bowel movements.

CASE REPORTS

Case 1.—A chauffeur, aged 37, was admitted on Dec. 20, 1946. For two years he had suffered from intermittent abdominal pain and vomiting, relieved at first by food and alkalis, but becoming increasingly severe. His general health and nutrition were good. A fractional test-meal showed a free hydrochloric acid rather below normal: a barium meal showed a coarse gastric mucous membrane with a moderately large gastric ulcer halfway up the lesser curvature. The ulcer was confirmed at gastroscopy, and at the same time I noticed a severe generalized chronic gastritis with much redundant purple œdematous mucosa. On Dec. 30 I performed an antecolic retroperistaltic gastrectomy of the Hofmeister type, removing rather more than three-fifths of the stomach. The duodenal stump was ligated and buried. The proximal jejunal loop was some 25 cm. from the duodenojejunal flexure to the top of the lesser curvature of the stomach. The findings of the X-ray and gastroscopic examinations were confirmed at operation, and it was noticed that the upper jejunum was rather bulky and œdematous. The patient made an uneventful recovery and was able to go home 17 days after the operation.

The diarrhœa did not commence until some weeks after he started work as a chauffeur. It has continued with intermissions for a year, but it has never been severe enough to make him lose even a day's work. Barium meal confirmed the tender area as being over the 20 cm. of jejunum immediately below the gastric stoma, and gastroscopy revealed the continued, though less severe, chronic gastritis with a rather similar appearance of all the visible jejunal mucosa. The X-ray picture showed a 'spiky' appearance of the jejunum (*Fig.* 464). This is perhaps characteristic of jejunitis as it appears in the radiographs of both patients. A more recent barium meal had similar findings, except that the tenderness was considerably less. Both examinations showed the usual post-gastrectomy rapid emptying rate of the stomach.

Fig. 464.—*Case* 1. Barium meal 12 months after gastrectomy, showing 'spiky' appearance of efferent jejunum.

The patient seems to be making a gradual recovery. He is taking an almost normal diet, but avoids fruit and bulky foods. His stools contain no pathogens and no occult blood. He has lost no weight, his pain is minimal and is very much less than before operation, and his only complaint is the persistent diarrhœa.

Case 2.—The patient, an office porter, 64 years of age, was admitted on July 5, 1947, with very severe upper abdominal pain and persistent vomiting. He gave a history of ulcer pain for some twenty years, and had had many medical treatments in many hospitals. In spite of careful gastric lavage he continued to vomit large quantities of blood-stained fluid. It was obvious that he had a severe pyloric stenosis, and next day I was able to confirm this at operation. The duodenum was completely occluded by a chronic duodenal ulcer which almost encircled its lumen. I performed a Hofmeister gastrectomy similar to that done in *Case* 1. He made an uninterrupted recovery and went home three weeks later, very much improved and free from pain. He remained well for almost six months, when he had what appeared to be an acute attack of food poisoning. He recovered from this in a few days but continued to have some left-sided abdominal discomfort and a loose bowel

movement after every meal. Again there were no pathogens found in his stool. There was almost complete achlorhydria on test-meal examination. X-ray

FIG. 465.—*Case* 2. Barium meal 6 months after gastrectomy, showing similar ' spiky ' appearance of efferent jejunum.

examination (*Fig.* 465) showed a rapid emptying rate and a ' spiky ' tender jejunum similar to that in *Case* 1. His severe kyphosis rendered him unsuitable for gastroscopy. He is now reasonably comfortable on small doses of liquid paraffin and bismuth and opium taken before meals, and has been able to continue his work after some three weeks' rest.

DISCUSSION

There is little reference to similar symptoms in the recent literature on the end-results of gastrectomy. In two recent comprehensive studies of end-results by Douglas (1947) at Hammersmith Hospital and Watson (1947) at Leicester Royal Infirmary, such a condition is not noted as having occurred. It is possible that my patients are in the process of developing jejunal ulcers, but the X-ray screening shows no point of particular tenderness. It is possible, too, that the relatively low loop of jejunum used for anastomosis is more readily irritated by unaltered food. However, I have performed exactly similar antecolic retroperistaltic Hofmeister gastrectomies on 148 out of 246 gastrectomies in the past seven years without any other of the patients developing such symptoms. That this type of operation predisposes to ulceration is disproved by a careful study by Kennedy and Reynolds (1946), who find that in anastomoses made 30–40 cm. from the ligament of Treitz the jejunum shows no more reaction to acid or to mechanical irritation of food than when the anastomosis is made to a more proximal segment.

I think that the condition is possibly an extension of a severe pre-existing hypertrophic gastritis which I know to have been present in the first case from my own gastroscopic findings.

SUMMARY

Two cases are described where chronic jejunitis followed partial gastrectomy and was characterized by persistent diarrhœa and vague left-sided abdominal pain without loss of weight. It is thought to be an extension of a pre-existing chronic gastritis.

I wish to thank Dr. F. G. Nicholas, Radiologist, Dulwich Hospital, for his help in the interpretation of the X-ray findings.

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A COMPLICATION OF CHOLECYSTGASTROSTOMY

FRUIT SKINS IN THE GALL-BLADDER

BY JOHN BORRIE, M.B.E.

THE following is an unusual complication of cholecystgastrostomy.

CASE REPORT

Fruit skins in gall-bladder, cholangitis, and choledocho-lithiasis.

S. R., aged 79 years, was admitted on Sept. 27, 1946 with a history of having had " a gall-bladder operation " in 1933. He was in excellent health until Christmas Day, 1945, since when he complained of very severe, intermittent, abdominal pain, bearing no relation to meals, situated in the right hypochondrium and also the right hypogastrium. There was no vomiting. He had been jaundiced at times during the past nine months, the last time being five days before admission. The urine had been dark, and the stools pale. Since the onset he had had eight rigors and had lost 4 st. in weight. He also had a recent onset of prostatic symptoms, with hesitancy, dribbling, and frequency, which was hourly by day and two-hourly by night. He had previously suffered from " bronchitis and emphysema ". His mother, his son, and his daughter all had had operations for gall-stones.

ON EXAMINATION.—He showed no clinical jaundice. He had obviously lost weight. There was a healed right paramedian abdominal scar from his previous gall-bladder operation. He was tender and rigid in the right hypochondrium. Rectally there was benign prostatic enlargement. His heart and lungs were clinically normal. The blood-pressure was 170/80 mm. Hg. White blood-count was 6700 c.mm. There were 2 oz. of residual urine which was sterile on culture and which contained no bile.

AT OPERATION (Nov. 5, 1946).—Under pentothal, gas, oxygen, and tubarine anæsthesia, laparotomy was

performed through a right Kocher incision by Mr. Maingot. On opening the abdomen, masses of adhesions were found extending between the transverse colon and the liver. These were gradually freed, revealing the previous operation to have been a cholecystgastrostomy. The gall-bladder, which was thickened, was enlarged to three times its normal size. The common duct was grossly dilated, thickened, and filled with palpable stones, ½–1 cm. in diameter.

The anastomosis between the fundus of the gall-bladder and pyloric end of the stomach, which was 2 cm. in diameter, was undone, the gastric opening being closed with four layers of catgut sutures reinforced by omentum.

The common bile-duct was next explored, multiple soft infected stones and mud being removed. A Maingot half-circle T drainage tube was inserted into the common duct.

Thereafter cholecystectomy was performed. The muscle layers were closed with catgut, and the skin with deknatel, a corrugated rubber drain being left down alongside the T-tube to the epiploic foramen.

POST-OPERATIVE COURSE.—The post-operative course was stormy. There was severe shock, which was aggravated by a plasma infusion rigor five hours after operation. His condition was fair until Nov. 8, when he collapsed and died. No post-mortem examination was granted.

THE GALL-BLADDER.—The specimen showed a typical picture of chronic inflammation. Judge our surprise on finding the lumen filled with neatly coiled rolls of organic tissue, like curled-up leaves of a tree (*Fig.* 466).

FIG. 466.—Chronically inflamed gall-bladder with coiled fruit skins. (Specimen now in the Museum of the Royal College of Surgeons of England.)

Report on the Foreign Bodies (Professor R. A. Willis, Royal College of Surgeons).—"Gall-bladder contains multiple elongated rolled-up foreign bodies, microscopical examination of which shows typical plant structure, proving them to be fruit skins."

DISCUSSION

I could find no case in the literature quite like this one.

In 1931 Enderlen described a patient who previously had had a cholecystgastrostomy on whom he subsequently operated, separating the anastomosis. From the gall-bladder oozed forth a thick viscid slime containing over a tablespoonful of bean husks, apple skin, red currants, pieces of potato, and root vegetables.

The more usual complications following cholecystgastrostomy are ascending cholangitis, stenosis of the stoma, foreign bodies in the biliary tract; or arise from secondary obstruction of the duodenum due to neoplastic enlargement of the head of the pancreas; or from a blocked cystic duct.

A short relevant bibliography is attached.

SUMMARY

A case of cholecystgastrostomy followed by cholangitis, choledocholithiasis, and fruit skins in the gall-bladder is described.

I wish to express my thanks to Mr. Rodney Maingot for his encouragement and permission to publish the case report; Mrs. Maingot for the colour transparency; and Professor R. A. Willis for his pathological report on the specimen.

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SPONTANEOUS VENTRAL HERNIA

TWO CASES OF PARA-INGUINAL HERNIA

BY JOHN GRIERSON AND AUBREY LEACOCK, BRITISH GUIANA

AMONG the less common varieties of hernia of the abdominal wall is a peritoneal sac, which, sprouting through a defect in the internal oblique and transversalis muscles, spreads beneath the external oblique medial to the anterior superior iliac spine. Two such herniæ are here reported.

CASE REPORTS

Case 1.—A fat and flabby Portuguese-Guianese widow of 59 was admitted to the Public Hospital, Georgetown, on Nov. 9, 1947, complaining of severe colicky abdominal pain for the last eight hours. She had vomited several times and although she had been given

an enema her bowels had not acted since the onset of the pain. Temperature was 98·4°, pulse 78. In the left iliac fossa there was a tense and tender mass, about 3 in. in diameter, stretching from near the anterior superior iliac spine to the region of the linea semilunaris. The mass lay mainly above the level of the anterior superior iliac spine and appeared to be in the substance of the abdominal wall. A tentative diagnosis of strangulated interstitial hernia was made.

AT OPERATION (J. G.).—Under spinal anæsthesia a large sac was found under the external oblique aponeurosis, containing deeply congested, but viable, loops of small intestine. The neck of the sac emerged through an opening in the internal oblique and transversalis muscles, about 1½ in. medial to the anterior superior iliac spine and about 1 in. above the internal inguinal ring. No inguinal hernia was found. The intestines were reduced, the sac excised, and the muscular defect repaired without difficulty.

PROGRESS.—Her post-operative course gave some anxiety for the first 48 hours and was prolonged by superficial wound sepsis and by a troublesome urinary infection. She was discharged on Dec. 14, the wound being soundly healed.

Case 2.—A male Patamona Amerindian, aged about 35, was admitted to the same hospital on Nov. 17, 1947, having travelled some 200 miles from Kaieteur Falls to have his herniæ repaired. He spoke no English, and no history could be elicited. He was a typical, short, broadly built Aboriginal Indian with very little subcutaneous fat. A reducible inguinal hernia was present, extending into the scrotum and almost reaching the upper pole of the testis. In addition there was a large swelling in the right iliac fossa, extending from the anterior superior iliac spine to the linea semilunaris and partly covering the region of the internal ring. This could easily be reduced through a neck which lay near the internal ring, but no obvious defect could be felt in the muscular abdominal wall. The sac appeared to lie beneath the external oblique aponeurosis. A diagnosis was made of indirect inguinal hernia with an interstitial extension.

AT OPERATION (A. L.).—Under spinal anæsthesia two entirely separate sacs were found. One was an elongated direct inguinal sac with a narrow neck, coming through a clearly defined gap in the posterior wall of the inguinal canal medial to the inferior epigastric vessels, and extending alongside the spermatic cord into the scrotum. The other, and much larger, sac emerged through a split in the fibres of internal oblique and transversalis about 1 in. above the internal ring, and extended widely under the external oblique aponeurosis, almost reaching the anterior superior iliac spine. The ilio-hypogastric nerve emerged through the defect with the sac. The spermatic cord and internal ring were normal. Both sacs contained loops of small intestine which were easily reduced. The sacs were excised, the defect in the internal oblique and transversalis was repaired, and the inguinal canal was repaired by suture of the transversalis fascia, followed by a Bassini repair coupled with Tanner's relaxing incision in the anterior layer of the rectus sheath.

Convalescence was uneventful.

DISCUSSION

This variety of hernia is not described in any of the standard works of reference obtainable in this somewhat far-flung outpost of the Empire.

Interstitial inguinal herniæ differ from the two cases described in that they emerge from the internal inguinal ring. Furthermore, the interstitial part of the sac is commonly developed as a diverticulum from an indirect inguinal sac, to which it is attached in such a manner that the two sacs have but one neck. Incomplete descent of the testis is often an associated abnormality.

Spiegelian hernia through the linea semilunaris cannot be confused with the herniæ described above, for in these the defect in the parietes lay unmistakably lateral to the semilunar line, in the broad expanse of the internal oblique and transversalis muscles.

Woliver and Scott (1944) describe a case similar to our own cases, and refer to previous reports, including a case described by Kronlein in 1876, under the name of para-inguinal interstitial hernia. However, a para-inguinal hernia must, of necessity, be interstitial, and it would appear sufficient to describe these herniæ as para-inguinal, implying that they occur beside the inguinal canal but do not emerge through any part of it.

In the cases of para-inguinal hernia previously reported, incarceration and strangulation have several times been found. The pre-operative diagnosis has usually been interstitial inguinal hernia, but the true state of affairs is easily recognized on exposing the sac. Surgical treatment presents no special difficulty.

Two possible aetiological factors have been described. Zimmerman and others, in observations on cadavers, describe " banding " of internal oblique and transversalis muscles as a not uncommon occurrence. Between the bundles of fibres potential defects were found to exist, and herniations of preperitoneal fat were sometimes found in the interstices between the bands. Woliver and Scott suggest that the vessels and nerves of the abdominal wall, in penetrating the muscular layers, may produce points of weakness through which a hernia might develop. However, in this region the segmental vessels and nerves lie anterior to the transversalis muscle, and although in passing through the internal oblique they may slightly weaken that muscle they can produce no defect in the transversalis muscle, some fault in which is presumably the primary factor in the development of a para-inguinal hernia. It does not appear that developmental anomalies could play any part in the aetiology of these herniæ.

The occurrence of a para-inguinal hernia in an Aboriginal Indian is of some interest, for this race seems peculiarly prone to develop bizarre herniæ of the inguinal region. Romiti (1932) has described four unusual interstitial herniæ in these people, and many more unrecorded cases have been seen in this Colony.

SUMMARY

Two cases of spontaneous ventral hernia are described, one of which was associated with a direct inguinal hernia. It is suggested that these rare herniæ form a distinct clinical entity best described as para-inguinal herniæ.

We are indebted to the Director of Medical Services of British Guiana for permission to publish these cases.

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A RADIOLOGICAL APPEARANCE OF THE PAPILLA VATERI IN PANCREATIC DISEASE

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With the increasing interest in the surgery of the pancreas, the radiological manifestations of the following case of pancreatic cancer seem worthy of recording. Not only are some features of that condition shown in the opaque meal, but the cholangiogram has produced an appearance with which we were hitherto unfamiliar and which we believe to be a sign of disease affecting the duodenal papilla.

CASE REPORT

Mrs. M. B., a woman of 50 years, who had suffered from polyuria, polydipsia, and loss of weight for one year, was admitted to the Ashford Hospital on Dec. 4, 1946. She was in early diabetic coma. The blood-sugar was 604 mg. per cent and the alkali reserve 20. After an initial satisfactory response to treatment (insulin, glucose, intravenous saline, and sodium lactate) the patient was stabilized in 17 days on a diet containing 150 g. carbohydrate, and protamine zinc insulin 30 units with soluble insulin 10 units daily.

Fig. 467.—Opaque meal to show the 'reversed-3 deformity' at the left lower angle of the third lumbar vertebra in a case of carcinoma of the pancreas.

Diarrhœa commenced during this period, the stools became pale, and jaundice supervened. Later, bile appeared in the urine and the serum-bilirubin rose to 4·7 mg. per cent (direct). At that time the serum alkaline phosphatase was 49 K.A. units and the fæcal fats as follows: Total 60·73 per cent, split 30·3 per cent, unsplit 30·4 per cent. The stools showed undigested muscle-fibres.

At Operation.—Laparotomy, performed on Jan. 21, 1947, revealed a mass in the head of the pancreas, but no demonstrable metastases. To relieve the deep jaundice cholecystostomy was carried out. With a view to partial pancreatectomy, a second operation was undertaken on Feb. 11. So dense were the peripancreatic adhesions that, after securing a portion of the pancreas for histological examination, it was found impossible to proceed with the radical resection.

Fig. 468.—Post-operative cholangiogram showing the characteristic malignant compression of the lower end of the common duct. The semilunar shadow over the left margin of the vertebral column outlines the swollen and displaced papilla vateri.

Progress.—The post-operative course was interrupted by the development of a pancreatic fistula. After temporary improvement, recurrence of vomiting and jaundice ensued and the patient died on June 17.

RADIOLOGICAL FINDINGS

a. **Opaque Meal** (Feb. 4).—A feature of the barium examination was the presence of the ' reversed-3 sign of Frostberg ', as seen near the left inferolateral angle of the third lumbar vertebral body in *Fig.* 467. In the present instance, this deformity occurred some distance from the usual situation of the normal duodenal exit of the biliary tract—as might be expected when the pancreatic head was shown at operation to be so pathologically distorted. However, to check whether the common bile-duct really was abnormally situated and to ascertain if the deformity of Frostberg actually appeared in the proximity of a displaced duodenal papilla, cholangiography was performed.

FIG. 469.—A further cholangiographic view of the same patient. To illustrate the lipiodol entering the duodenum around the semilunar shadow and showing the intimate relation of that shadow to the lower end of the bile-duct.

b. **Cholangiography** (Jan. 22).—In *Fig.* 468 is reproduced a post-operative cholangiogram, performed through a tube inserted into the gall-bladder at the time of the first laparotomy. The common duct is relatively constricted from the upper margin of the interspace between the second and third lumbar vertebræ. As its lower end leads to the site where the ' reversed-3 ' was detected in the opaque meal, the Frostberg sign coincides with the cholangiographic situation of the duodenal papilla.

c. **A Duodenal Appearance.**—Especially worthy of attention is the semicircular shadow at the angle formed by the junction of the lower and left lateral borders of the body of the third lumbar vertebra (*Fig.* 468). Occurring only during the cholangiography, this peculiar opacity is obviously due to the lipiodol employed for that examination. We note its position—namely, where Frostberg's sign appeared—and, as the cholangiogram indicates, in close relation to the lower extremity of the common bile-duct. Moreover, a later film (*Fig.* 469) shows that one limb of the semilunar shadow is in direct continuity with the intestinal pattern, as revealed by the iodized oil.

DISCUSSION

Let us briefly consider the indentation into the duodenal wall to which Nils Frostberg directed attention in 1938. From its shape, this protrusion into the wall of the duodenum has come to be known as the ' reversed-3 deformity '. More than once it has been stated to be a sign of cancer of the pancreas, but in Frostberg's original article we see an account of three cases—two malignant and one inflammatory. He makes it clear that the changes described are not typical of any particular disease of the pancreas. They may occur, Frostberg emphasizes, both in the case of tumour or pancreatitis, and possibly also in simple œdema. The last remark is full of interest.

All who use the cystoscope are well aware of the great intravesical œdema, bulging, and protrusion which tell of ureteric disease—whether it be of calculous, malignant, or inflammatory nature. The swelling (seldom seen to advantage after death) is diagnostic of an intra-ureteric lesion, but not always of its cause. Many must have wondered what the intraduodenal protrusion of the bile and pancreatic ducts looks like under similar malignant, calculous, or inflammatory conditions of the pancreas. But, as yet, we have no satisfactory endoscope for viewing the duodenal mucosa at the site of its papilla.

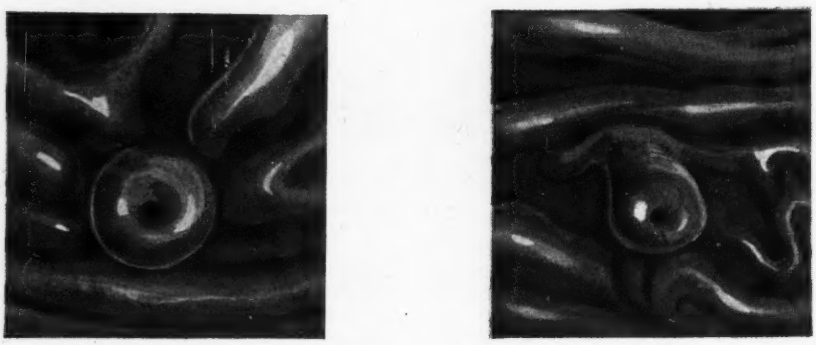

FIG. 470.—Representations of the appearances of the duodenal mucosa at the site of the papilla under pathological states of the pancreas. (*After Delfor del Valle.*)

In the Argentine, however, Professor Delfor del Valle has for many years been studying the inflammatory lesions of this particular region. Moreover, he has freely illustrated the appearances of the pathological duodenal mucosa as seen during life. *Fig.* 470 shows two of his illustrations. *Fig.* 471 shows the post-mortem features of a personal case of pancreatic cancer. In each we observe the great swelling around the papilla.

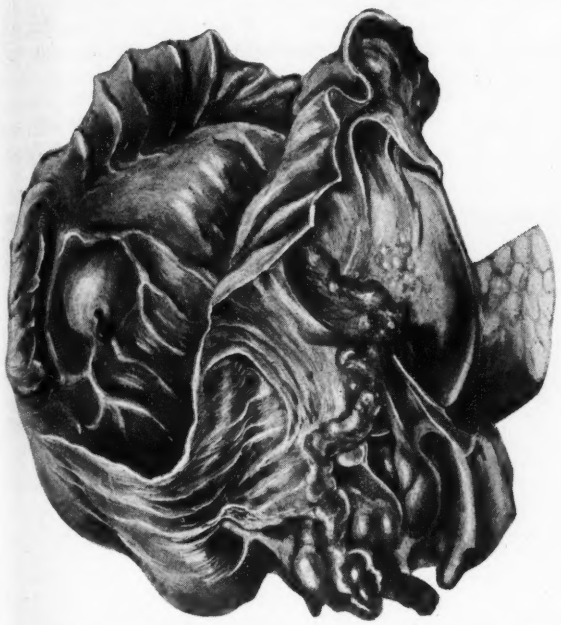

FIG. 471.—Post-mortem appearances of the swollen lower end of the common bile-duct in a case of carcinoma of the pancreas.

Reverting once more to the semilunar shadow, which we have described (*Figs.* 468, 469), one must reflect on its interpretation. It occurred in a patient known to have carcinoma of the pancreatic head and at the cholangiographically proved exit of the common bile-duct. Considering not only its site, but also its almost circular shape, we conclude that it represents the course of the lipiodol as it partially encircles one of those peripapillary projections to which Delfor del Valle has directed so much attention (1939). It seems, as in Frostberg's experience with the 'reversed-3 deformity', that the semicircular shadow is not a sign of pancreatic cancer *per se*, but might be expected in any kind of pancreatic disease—provided that it involves the ducts and gives sufficient swelling of their exit into the duodenum.

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CHRONIC NON-SPECIFIC ULCERATION OF CÆCUM

BY A. H. SANGSTER

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CHRONIC non-specific ulceration of the cæcum and colon is an uncommon condition. Barlow (1941) wrote that he found only 78 reported cases. Rosser (1944) gave details of 2 more cases, and 2 others were reported at the meeting which heard Dr. Rosser's paper.

Because the diagnosis has never been made before operation it seems worth recording cases.

CASE REPORT

B. McD., No. 1843, was seen at the Out-patient Department on March 9, 1948. He complained of pain in the right side of the abdomen which had been present for three days. It was severe and colicky. Vomiting and nausea were present. He had been constipated until the morning of examination, when he had a loose motion.

Past history was negative except for appendicectomy in 1926.

ON EXAMINATION.—This revealed a tender mass about 2 in. long and 1 in. broad just above McBurney's point. It was lying transversely. The patient was admitted to hospital with a diagnosis of carcinoma of the colon causing intestinal obstruction.

Examination the next day (March 10) revealed no mass. The patient was free from pain and felt quite comfortable.

Two days later a barium enema was given and the radiologist reported: "The appearances suggested an intussusception, but more normal appearance was present later." (*Fig.* 472.)

AT OPERATION.—After a full course of phthalylsulphathiazole, operation was undertaken on March 18.

Inspection of the cæcum through a right paramedian incision showed an area of thickened bowel wall. The peritoneum over this area was stippled and had lost its shine. This area was almost opposite the ileocæcal valve. It was about one inch by half an inch.

This area could with ease be invaginated into the cæcum and when this was done it was 'picked up' by the cæcum and passed up into the colon as an intussusception.

A hemicolectomy and a side-to-side anastomosis was performed.

Uninterrupted recovery followed and the patient was discharged on March 29.

PATHOLOGY.—The pathological report reads: "Single shallow ulcer, 10 mm. in diameter, in most dependent part of cæcum with undermined edges and granular base. No associated lymph-nodes.

"The microscopical appearances are wholly consistent with the condition known as 'solitary ulcer of the cæcum' (*Fig.* 473). The edges of the ulcer are undermined and the base is composed of a layer of necrotic debris on a thin zone of granulation tissue. The submucosa in the vicinity of the ulcer is greatly thickened, œdematous, and hyalinized, with a few foreign-body giant cells. Examination under polarized light fails to reveal any fragments of catgut or other anisotropic substances.

"*Cæcum and Ascending Colon:* 'Solitary ulcer of cæcum.'"

DISCUSSION

Solitary ulcer or chronic non-specific ulcer of the colon is an interesting condition. The cause is not known; though a number of theories have been put forward (Cameron, 1939), none of them bear critical examination because these ulcers occur so widely, e.g., 16 per cent are found in the pelvic colon.

FIG. 472.—Barium enema, showing intussusception at cæcum.

The mortality of unoperated cases is 10 per cent. Because of the tendency to perforate, the overall mortality in one series was 57 per cent.

The ideal treatment is excision of the affected area of the colon, but perforation may make this too dangerous.

I wish to express my thanks to Dr. W. Brian Davis, Director of the Pathological Department, Victoria Infirmary, Glasgow, who examined the sections, made the photomicrograph, and reduced the X-ray pictures.

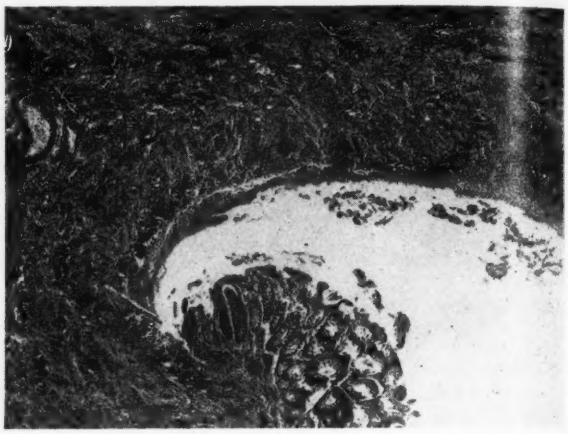

FIG. 473.—Photomicrograph of section through ulcer base, showing undermining of normal mucosa.

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REVIEWS AND NOTICES OF BOOKS

Textbook of Genito-urinary Surgery. Edited by H. P. WINSBURY-WHITE, M.B., Ch.B., F.R.C.S. (Eng. and Edin.), Surgeon, St. Paul's Hospital for Genito-urinary Diseases, London; etc. 9⅝ × 6⅞ in. Pp. 1046 + xvi, with 451 illustrations, many in full colour. 1948. Edinburgh: E. & S. Livingstone Ltd. 90s. net.

THE publication of this monumental work marks a further stage in the establishment of urology as a specialty in this country. The need for this has become increasingly apparent during the past years from the developments in diagnosis, operative technique, and special instruments no less than by the growing number of surgeons who have made themselves competent to apply these aids to the surgery of the genito-urinary tract. That it is beyond the powers of one man to give a comprehensive and yet detailed description of all the branches of the subject at the present time is evident when one studies a work by a single author. The men selected to write this book are all well known as specialists in their subject; they have been welded together into a team without undue repetition or contradiction by the skill of the Editor, who is himself one of the principal contributors. It is inevitable that literary styles must differ, but each chapter is written from a practical point of view and is designed to afford the maximum information to the reader.

When there is so much that is good it would be invidious to select any section for particular praise, but we cannot refrain from drawing attention to the excellence of all the articles on the male urethra written by the late F. McG. Loughnane; he will be difficult to follow in subsequent editions, but these chapters are never likely to need much revision.

Points of criticism reflect mainly the variance of opinion about the use of different procedures; whilst we consider that the case in favour of plastic operations on hydronephrosis is not presented in a good light, and that the description of the operative technique for the procedure is inadequate, we can understand that bad results would inevitably follow a plastic operation on such a kidney as that depicted in *Fig.* 31. Despite an excellent description of the pathological anatomy of the condition, with an exposure of the theory of aberrant vessels as its cause, there is no discussion on the alternative dynamic theory of causation.

The subject of prostatic obstruction has become a vast one, and no less than eight authors contribute to its description; there is, however, a valuable summing up in the form of a commentary on the various surgical procedures.

The modern and progressive outlook of the work is well exemplified by the stress laid on the need for sanatorium treatment in genito-urinary tuberculosis, and on the co-option of a physician to write on glycosuria in genito-urinary surgery.

There are bound to be some omissions, and we have searched in vain for an account of Hunner's ulcer such as one would expect to find in a book of this size. Some would prefer the next edition to be in two volumes of more convenient size, but there may be practical considerations which prevent this.

The whole work is well illustrated both in black and white and colour and is a striking tribute to the publisher's art. It is well documented and is a volume of which British urologists can be proud. We can recommend it as one of the essentials to any surgeon practising urology.

Treatise on Surgical Infections. By FRANK LAMONT MELENEY, M.D., Associate Professor of Clinical Surgery, College of Physicians and Surgeons, Columbia University; Associate Visiting Surgeon, Presbyterian Hospital, New York. 9¼ × 6 in. Pp. 713 + xvi, with numerous illustrations. 1948. New York: Oxford University Press. 63s. net.

THIS comprehensive monograph of over 700 pages covers the field of infection in wounds from the earliest times to the present. After a fascinating chapter on the historical side of infection, the author, who is a practising surgeon, deals with the classification of infections and the problem of sterilization.

The relative merits of various suture materials are discussed and the question of infection introduced by catgut into deep wounds is thoroughly examined.

The primary and secondary defences of the body are set out in their proper perspective, and the author considers that the process of natural selection by which the fittest survive, weeding out by death the more susceptible individual, may result in a genetic pattern of resistance to infection.

The nature and properties of antibodies is dealt with at length.

The surgical principles in the treatment of infection are set out in a masterly way, the importance of tissue trauma is stressed, and the detrimental effect of tissue tension emphasized. These principles are all too often forgotten to-day. Chemotherapy and antibiotics are discussed, and the author rightly stresses the point that these agents should not be used to replace inadequate surgery.

The book is a wealth of information and the practical surgeon of to-day will find much information which it is difficult to acquire elsewhere.

A very sound production.

The Digestive Tract in Roentgenology. By JACOB BUCKSTEIN, M.D., Assistant Professor of Clinical Medicine, Cornell University Medical College; etc. 10 × 7 in. Pp. 889 + xvi, with 659 illustrations. 1948. Philadelphia and London: J. B. Lippincott Co. £5 net.

THE title is an understatement of the scope of this admirable book. While the main emphasis is naturally on roentgenological technique and roentgenological appearances, pertinent anatomical, clinical, and pathological data are given in such a way as to produce a logical sequence. This makes the subject matter much easier to read, to understand, and to remember. As a further stimulus to study and as an aid to memory are the illustrative cases which follow each radiological description.

A book on radiology must necessarily be well illustrated, and in this respect Buckstein's book is excellent. Interest in the radiological illustrations is enhanced by the accompanying case histories, and in many instances photographs of pathological specimens complete the clinical record.

The style of writing is clear; each subject is introduced with a historical note often on general rather than on radiological lines. A useful bibliography follows every chapter.

The author obviously has a vast clinical experience on which he has drawn to provide a practical reference book for both common and rare diseases and radiological abnormalities of the bowel.

There is very little to criticize in the text. Many surgeons may doubt the statement made in Chapter XXVI that the rate of emptying of the stomach after gastrojejunostomy or gastrectomy is significantly hurried by making a large stoma. The reviewer is of the opinion that provided the stoma is of wider diameter than the jejunum, the emptying rate is probably more influenced by the tonus and motor activity of the stomach and jejunum.

This is a book that most radiologists would read with profit. More than that, however, it is a book which can be warmly recommended to any surgeon or physician interested in diseases of the alimentary tract. He will read it with much greater ease and pleasure than the rather formidable size of the book would suggest.

Cineplasty. By HENRY H. KESSLER, M.D., Ph.D., Orthopædic and Amputation Consultant to the Office of Vocational Rehabilitation, U.S.A. 9 × 6 in. Pp. 201 + xi, with 199 illustrations. 1948. Springfield, Ill.: C. C. Thomas. (Oxford: Blackwell Scientific Publications.) 35s. net.

"DURING World War II, about 1800 military casualties in the U.S.A. resulted in amputation. During the same time a minimum of 120,000 civilians suffered amputation from disease, injury or congenital deformity." These remarks, taken from Dr. Kessler's preface, form the *raison d'être* for his comprehensive book on Cineplasty.

In America, at his Clinic in Newark, Dr. Kessler has been for many years the pioneer in this branch of surgery. The patient is admitted and treated, and when this is completed he is found a suitable job. His disability is then assessed by a Board, so that the whole question of impending litigation and compensation is eliminated from the patient's mind. Indeed, as the Foreword by Vice-Admiral Ross T. McIntire, Surgeon General United States Navy, indicates, his services were utilized by the U.S. Navy during the war, and I now understand that every State in the U.S.A. has adopted his methods for dealing with amputees.

This is, therefore, an authoritative book, indispensable to those engaged in restoring amputees to become useful, happy, and economic units within the framework of society.

For the amputee, the most important problem is to furnish him with a prosthesis that will meet his own particular social and economic needs: for the orthopædic surgeon, how best to utilize the remaining muscles of the amputation stump to work and control the prosthesis.

The aim of all these operative procedures is to provide a stump of adequate length and shape to fit the bucket of the artificial arm or leg. The scar is so fashioned that it is free from friction from the bucket, and the leverage of the stump provides movement for the artificial appliance. The art of cineplasty is, then, to fashion the available muscles so that they can be used to impart detailed movements to the prosthesis.

Rehabilitation forms an important part of the process, not only in physical restoration directed towards the appearance, utility, and range of activity of the prosthesis, but also in such matters as training, vocational guidance, and in the selection of suitable work within the scope of the individual.

The Radiology of Bones and Joints. By JAMES F. BRAILSFORD, M.D., Ph.D., F.R.C.P., F.I.C.S., Director of Radiological Studies in Living Anatomy, The University of Birmingham; etc. Fourth edition. 9⅝ × 7¼ in. Pp. 760 + xvi, with 615 illustrations. 1948. London: J. & A. Churchill Ltd. 63s. net.

THIS is the fourth edition of this well-known and standard work since its first appearance in 1934. It was translated into Spanish in 1947, and when materials are in greater supply there is no doubt it will be translated into other languages.

In spite of the quotation from Roentgen's rectorial address delivered at Würzburg in 1894, before the discovery of X rays the following year, which the author so modestly places in the preface, it will be many years before this book ceases to be the vade-mecum of all radiologists. Moreover when Roentgen gave the address he would have been astonished if he had known that the following year he would have made an epoch-making discovery, which was to revolutionize medicine in all its branches, and provide the penetrating vision which was necessary to study the anatomy and physiology of deeper tissues and organs; and indirectly to place a revolutionary therapeutic agent in the hands of those who are treating disease, particularly that which is recognized as malignant. Moreover the industries dealing with metals, and many others affecting the welfare of mankind in all its phases, at the same time received what was to be of inestimable benefit to their progress. Roentgen said: "The scientist must consider the possibility which usually amounts to a certainty, that his work will be superseded by others, within a relatively short time, that his methods will be improved upon, and that the new results will be more accurate, and the memory of his life and work will gradually disappear."

The third edition of this book was published in 1945, the year in which the jubilee of Roentgen's discovery was celebrated. Fortunately by the German surrender having occurred on May 4, the celebrations could be made more happily on November 8, and in all countries of the world.

The importance of radiology as an adjunct in diagnosis is shown by the demand that its help should be available in all health centres. It must, however, be realized that no mechanical aid to diagnosis can replace the clinical examination and interpretation of what is found. A radiologist must be a competent clinician, and more so than ever to-day, if his department is not "a closed one" and he is overwhelmed by a flood of requests reading "Please X-ray" whatever organ may be mentioned. Every request should be accompanied by a report of a thorough clinical examination and conclusions to be drawn. It has maliciously been said that a physician began his out-patient clinic by requesting all those who had indigestion to go to be X-rayed, and bring the films with them before consulting him for a clinical examination.

And though it is desirable and essential that the clinician should study the radiographs himself in consultation with the radiologist, he should not favour the formation of a radiological service run by his own department, otherwise all 'border-line' cases will be missed. Herein lie the pitfalls of mass radiology and the X-ray findings at tuberculosis dispensaries, etc. The danger is that such an aid to diagnosis as X rays may be carried out by those who are neither qualified and trained radiologists nor clinicians, to the detriment of the patient. Be that as it may, the present book should be in the library of every hospital to be consulted by senior and juniors alike as a book of reference.

The X-ray appearance and its interpretation of bones and joints apart from its intrinsic difficulties may in many cases furnish the most important clue to the diagnosis of the clinical condition, whatever the organ may be which has supplied the presenting symptom or sign. That the author is fully aware of this, and so stresses the clinical findings throughout, can be shown by his remarks on arthritis, sciatica, disk lesions, and neoplasms. His chapters on 'The Spine' in its different parts, including the dystrophies and lesions in general, compresses a wealth of clinical and radiological findings into a hundred pages which should be read, re-read, and pondered by all clinicians and aspirants to a radiological career.

The section of the book on bone tumours, not merely neoplasms, is what one would expect from such an authority as the author, with his unrivalled experience amongst a large industrial community and the amount of thought he has given to the subject in his numerous papers and research.

The index has been most carefully and thoroughly drawn up, which is so important in such a classical book of reference, which may ultimately be replaced by another.

It will be many years before this can be done, and it will not have so much invaluable information packed into such a small space.

Fuss und Bein. Ihre Erkrankungen und deren Behandlung. By Prof. Dr. med. GEORG HOHMANN, Director of Orthopædic Clinic, University, Munich. Fourth edition. 9¾ × 6½ in. Pp. 504 + viii, with 45 illustrations. 1948. Berlin: Springer. DM. 36; bound DM. 39.

ONE is glad to see a German text-book at last attaining the fourth edition which bomb damage had so long delayed. The lack of paper and shortage of printing facilities are understandable, but the pages of this book reveal another deprivation. Those who have not seen the earlier editions will nevertheless know what to expect; a reference in the text to the views of a host of authorities on almost every aspect of regionally applied orthopædics. What he will be sorry to find is that there has been little access to recent literature—certainly to books in the English language. The bibliographical pages are, for us, chiefly remarkable for the lacunæ, and it is difficult to know what class of readers here can profitably use the book.

It might be invidious to particularize, but looking at some of the 'new' chapters it is difficult to discover anything much that could not have been written in 1939.

No doubt the book is needed in Germany and will serve a very useful purpose. No doubt, too, the author is looking forward to a revised fifth edition.

Demonstrations of Physical Signs in Clinical Surgery. By HAMILTON BAILEY, F.R.C.S. (Eng.), F.A.C.S., F.I.C.S., F.R.S.E., Surgeon and Surgeon-in-Charge of the Genito-urinary Department, Royal Northern Hospital, London; etc. Eleventh edition. To be issued in Four Parts. 8¾ × 5⅝ in. Part II, Pp. 101–196 + iv, with 182 illustrations, a large number in colour. Part III, Pp. 197–304 + iv, with 160 illustrations, a large number in colour. 1948. Bristol: John Wright & Sons Ltd. 8s. 6d. each part.

PARTS II and III of this invaluable student's aid have followed closely on *Part I* and fully maintain its high standard. They cover the neck, thorax, hand, abdomen, rectum, and male generative organs.

The wealth of illustrations, both in black and white and colour, adds greatly both to the usefulness and attractiveness of the work. We look forward to the publication of *Part IV* and of a binding case worthy of the whole series.

A Surgeon s Guide to Local Anæsthesia. By C. E. CORLETTE, M.D., Ch.M. (Syd.), F.R.A.C.S., Consulting Surgeon, Sydney Hospital, etc. $8\frac{3}{4} \times 5\frac{5}{8}$ in. Pp. 355 + xi, with 200 illustrations. 1948. Bristol: John Wright & Sons Ltd. 30s. net.

THIS book is written by a surgeon for surgeons and is a manual of shockless surgery. The author, who has had a vast experience of local anæsthesia in the hospitals at Sydney and in the country round about, speaks authoritatively and has many practical suggestions to give the reader. Every part of the body is considered from the point of view of local anæsthesia.

The author rightly stresses that the patient who is to have local anæsthesia requires the same preparation as one who is to receive a general anæsthetic.

A very useful chapter is devoted to the preparation and measurement of different types of local anæsthesia. There is too great a tendency to rely on prepared solutions without ever attempting to prove their composition or sterility.

Injection technique is described in detail and the various methods of injection are described and illustrated. Field-block by latticing is given its proper place.

The author gives his technique for such operations as prostatectomy, hysterectomy, ruptured ectopic pregnancy, Cæsarean section, and rectal operations. Few of these operations would be undertaken in England under local anæsthesia, but this is perhaps due to the fact that the surgeon in this country has the assistance of the best anæsthetists in the world.

The book is well illustrated and written in a clear, lucid style, and it should prove of value to surgeons who are interested in local anæsthesia.

Modern Surgery for Nurses. Edited by F. WILSON HARLOW, M.B., B.S. (Durham), F.R.C.S. (Eng.), Surgeon, Royal Isle of Wight County Hospital, etc. With a Foreword by Sir LANCELOT E. BARRINGTON-WARD. $8\frac{1}{2} \times 5\frac{1}{2}$ in. Pp. 795 + xxiv, with 429 illustrations. London: William Heinemann Medical Books Ltd. 25s. net.

THE Preface states that "This work is an attempt to present to the nursing profession a complete survey of modern surgery and surgical procedures." This is, to say the least, ambitious and deserves the motto *per ardua ad astra*, so the book must be examined critically to see if and how it falls short of its ideal.

Throughout the work physiological principles are not sufficiently stressed. The first chapter is on hæmorrhage and surgical shock—what might be called the 'shock-hæmorrhage syndrome', and the reason for considering them as a syndrome should be stressed. In considering hæmorrhage, the natural and artificial means of its arrest should be given as well as the temporary and permanent methods, and the point made that a permanent arrest can only be attained by natural means.

When discussing blood transfusion the signs and symptoms of incompatibility are not mentioned. These are surely more important to the nurse than "never add cell agglutinogens which were not there before". Moreover, is Horrock's glass cannula (*Fig.* 10) ever used now in modern surgery?

The definition of a simple fracture is stated as "The bone is broken into two fragments"; this must be very modern, but it is wrong. There is no mention of controlling the accuracy of reduction by X-rays, yet this must be more important than using it as an aid to what is often an obvious diagnosis. The interposition of periosteum and soft tissues is surely a cause for non-union more often than inadequate fixation. The ambulatory treatment of fractures is still modern. One wonders if tight splinting is a cause, as stated, for myositis ossificans. It must leave a curious impression on the mind of a nurse to read in the treatment of compound fractures that "the deeper parts of the wound are wiped clean with sterile swabs and if necessary *débrided*". It might conjure up reminiscences of some wartime marriages, but then '*debrided*' is not a word so let it pass.

The clinical condition of concussion is described as "shock with slow shallow respirations; varying degrees of paralysis of the limbs . . . the pulse is rapid, weak, and irregular"—so this must have been a fatal case. Again, what will be the criticism of the modern neuro-surgical nurse to read that "operative treatment for fractures of the base of the skull is *of course* out of the question."

Débridement does not "mean excision of all dead or damaged tissue in which sepsis may intervene". The term was first used by Desault (1789) and later by Napoleon's surgeon, General Larry (1812). It simply means enlargement of the wound in order to explore it and effect adequate drainage. Excision of wounds was first done in the 1914–18 war, so a mere century is the difference in time between débridement and excision.

Nor is it "modern" to leave a potentially infected wound "completely open and no immediate attempt at skin closure made", yet all modern surgeons would agree that skin, even if it has to be grafted, is still the best dressing for a potentially infected wound which has been adequately treated by modern methods.

In discussing pyæmia it seems rather fatuous to read "amputation is sometimes necessary to eradicate the primary focus" when the condition is already established, and the example taken of "metastatic abscesses should be opened and drained when accessible, as for example example infected joints." A no more difficult and unsatisfactory example could be given to a nurse either in training or when she has "passed on to senior and more responsible duties."

Infective gangrene is said to be "caused by the devitalizing action of bacterial toxins and also deficient circulation due to the pressure produced by inflammatory swelling." The deficient circulation is surely the determining factor and the devitalizing action is a secondary one. Nor does a text-book of modern surgery seem the place to state that penicillin, magnesium sulphate, or any other agent can "draw the pus to the surface and prevent extension of the area involved."

It is refreshing to see on p. 102 that credit is given to Winnett Orr for the closed method of dealing with osteomyelitis, whereas on p. 34 the method has been credited to Trueta. There is no excuse for historical inexactitude.

In dealing with appendicitis, a condition with which every trained nurse is very familiar, it is stated that "a fæcal fistula, due to breaking down of the appendicular stump and leakage from the cæcum occurs." This may be so, but surely no modern surgeon would agree, as is stated on p. 504, that fæcal fistula "develops in 80 per cent of cases after operations for gangrenous appendicitis". Nor would a modern surgeon agree that "burst abdomen . . . occurs especially in an acute intussusception because it has been of necessity hastily sewn up".

The articles dealing with "specialist" nursing will be very helpful to the nurse, as in the early years they do find it difficult to appreciate the finer points in "specialist" nursing. All that the specialist asks for is a nurse with a good general training in basic principles and essentials, and if of sufficient intelligence he will train her in his own peculiarities.

The orthopædist, however, would object that even a nurse should be told that torticollis is due "to contraction of one sternomastoid muscle" (p. 306) and a modern anæsthetist might well be horrified to read that a preliminary tracheotomy is advisable to prevent aspiration pneumonia in the operative removal of the upper jaw (p. 395).

In the chapter on surgical technique, which tends to become surgical ritual with all its pitfalls, there is no

mention of banning the ward blankets from the operating theatre, nor that the dressings of wounds in the wards should be delayed a definite time, after the sweeping and dusting, for obvious reasons.

It is on the whole difficult to understand what useful purpose this book will serve. The training of the nurse is sufficiently difficult in these days of shortage of man power, and discussions on the status of the student nurse.

Whatever the outcome of these discussions may be, the one essential is the training in the basic principles of anatomy, physiology, and pathology which must of necessity be of an elementary standard but sufficient for her to understand what it is that she is endeavouring to do in the pre- and post-operative treatment. There is no need to burden her education with details of surgical controversy but to be instructed in established principles with correct definition and application are her right and deserts.

Readers of this book will form their own opinion as to whether the ideals attempted have been attained.

Medical Research in War. Report of the Medical Research Council for the Years 1939–45. 9⅝ × 6 in. Pp. 455. 1948. London: H.M. Stationery Office. 7s. 6d. net.

IN due course the *Official Medical History of the Second World War* will be compiled and published, but none of its contents can make a wider or stronger appeal to the medical profession, or indeed to the public at large, than this account of the many and varied activities of the Medical Research Council during the war years. It is unfortunate that as a rule official records make their appearance so long after the event—so long, in fact, that interest is inclined to be rather on the wane by the time they are published. The present Report is therefore doubly welcome, for its timely publication as well as for its absorbing interest.

The many encouragements which are now given to the best of our young men to gain experience in the methods of research by working in various centres abroad suggest to those who are not well informed that there is little or nothing for them to learn at home. That we are incapable of original thought and lacking in mechanical ingenuity ranks almost as a popular fallacy, or at least as a poisonous misconception to which this book can provide a potent antidote.

It is impossible in a brief review to do justice to the surprising number and variety of the problems presented not only by the medical but also by the fighting services, in which the assistance of the Medical Research Council was of the greatest possible value. One naturally expects to find in the Report an account of the evolution of the treatment of wounds and burns; references to researches on shock and crushing injuries and on war diseases, including infective hepatitis and serum jaundice; the clinical trials of the sulphonamides; and the whole story of penicillin—and one is not disappointed. But comparatively few can have known of the liaison between the Medical Research Council and the Fighting Services which led to improvements in the design of tanks, gun-sights, and instrument panels, and in clothing and seating so as to increase efficiency and avoid fatigue in Director crews. These are but examples of the fruits of the constant collaboration between fighting men and scientific workers. Much that is of interest to physiologists was discovered with regard to high-altitude flying and deep-sea diving, and also about the responses of the body to extremes of temperature and humidity.

For the benefit of the civil population, as well as of service personnel, investigations were made into food values and dietetic (including vitamin) requirements; into improved methods of selecting individuals for special occupations in industry or for certain duties in the services; into the problems of fatigue due to environmental, general physical, visual, or psychological causes; and into the prevention of industrial accidents and the protection of service personnel. It is encouraging to know that both civil administrators and Service Departments had begun to establish working relationships with medical research workers even before the war; and it is to be hoped that the experience they have gained of collaborating under the conditions of Active Service will have established the necessity for perpetuating the closest possible association between them in peace time also.

Any time and trouble devoted to the study of the Report will be richly rewarded, for the work of the numerous groups of research workers has been skilfully summarized so as to make even technical details entertaining; and the whole Report presented in so unassuming a fashion as to be the near approach to understatement which the discerning reader will be quick to appreciate. It is, however, very much more than a mere record of the achievements of some of the back-room boys, and as a book of reference it will be of permanent value to research workers in many fields.

BOOK NOTICES

[*The Editorial Committee acknowledge with thanks the receipt of the following volumes. A selection will be made from these for review, precedence being given to new books and to those having the greatest interest to our readers.*]

Plastic and Reconstructive Surgery. By EARL CALVIN PADGETT, M.D., F.A.C.S., Professor of Clinical Surgery, University of Kansas School of Medicine. With the collaboration of KATHRYN LYLE STEPHENSON, M.D., Instructor in Plastic Surgery, Tulane University of Louisiana, New Orleans. 11 × 8½ in. Pp. 945 + xxi, with 479 illustrations. 1948. Springfield, Ill.: Charles C. Thomas. (Oxford: Blackwell Scientific Publications Ltd.) £6 6s.

The Principles and Practice of Rectal Surgery. By WILLIAM B. GABRIEL, M.S. Lond., F.R.C.S. (Eng.), Surgeon to St. Mark's Hospital for Cancer, Fistula, and other Diseases of the Rectum; Surgeon to the Royal Northern Hospital. Fourth edition. 9⅝ × 6 in. Pp. 508 + x, with 11 coloured plates and 278 text illustrations, some coloured. 1948. London: H. K. Lewis & Co. Ltd. 45s. net.

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